DIRECT MEASUREMENT OF STRAIN IN
CONCRETE PAVEMENT STEEL

J. S. Bereznicki 1959

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DIRECT MEASUREMENT OF STRAIN IN CONCRETE PAVEMENT STEEL

A DISSERTATION
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

DEPARTMENT OF CIVIL ENGINEERING

by

JOSEPH A. BERESNICKI, B.Sc.

EDMONTON, ALBERTA
April [illegible]

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JOSEPH S. BEREZNICKI, B.Sc.

EDMONTON, ALBERTA
April 2, 1959

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Direct Measurement of Strain in Concrete Pavement Steel" submitted by Joseph S. Bereznicki, B.Sc. in partial fulfilment of the requirements for the degree of Master of Science.

Date..April 2, 1959..

I. ABSTRACT

Beginning in the fall of 1958 an investigation was undertaken to study the behaviour of the concrete pavement with reference to temperature changes. This experimental concrete strip consisting of unreinforced, reinforced and continuously reinforced concrete slabs was situated on the Trans-Canada Highway in Bowness, near Calgary, Alberta. The depth of the slab varied from 6 to 8 inches and the steel percentage from 0 to 0.815.

Instrumentation was planned and installed in order to observe conditions at cracks in the reinforced and continuously reinforced concrete pavements. Measurements were made of the strain in the reinforcing steel and the accompanying crack widths at various slab temperatures encountered during the months of October 1958 to March 1959.

The results of this investigation indicate that cracks in the interior section of the continuously reinforced concrete pavement opened to objectionable widths and the reinforcing steel spanning the cracks yields in tension due to a temperature drop varying from 50 to 75 degrees Fahrenheit. The temperature drop at which the reinforcing steel yielded in tension depended directly on the amount of longitudinal reinforcement. On the basis of the data obtained there is an indication that the pavement design should be based on the total area of the steel if yieldin of the steel is to be prevented at shrinkage cracks.

ACKNOWLEDGEMENTS

This investigation was made possible by the sponsorship of the Research Council of Alberta and the technical assistance of the Alberta Department of Highways.

The author wishes to express appreciation to Dr. G. Ford and Professor S. Kennedy for their guidance and encouragement throughout the course of the investigation and their constructive criticism during writing of this manuscript, and to Professor E. Brooker, who gave so freely of his time to assist in all phases of the project. Also to Mr. W. Babowal, B.Sc. and Mr. F. Vaneldik who assisted in the preparation and instrumentation of reinforcing bars, and to Mr. H. H. Rix, B.Sc. of the Research Council of Alberta who took all readings when the author was away.

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II. INTRODUCTION

Up until the present time, highway departments in Western Canada have favoured asphalt pavements on main highways because of economic considerations. However, recent developments in pavement technology suggest that certain types of concrete pavements may be used economically in some parts of the Province of Alberta.

In 1954 the Alberta Department of Highways constructed an unreinforced concrete test road just north of Calgary to evaluate the economics and merits of a rigid pavement. This program was continued in 1958 by the construction of a second test road composed of unreinforced, reinforced and continuously reinforced sections. This test road is a part of Highway No. 1, west of Calgary.

Under the auspices of the Research Council of Alberta, the instrumentation of the test road was designed and installed. The instrumentation consisted of control points to measure horizontal and vertical movement of the slab, gage points to measure the width of instigated cracks, thermocouples to measure slab temperature and "SR-4" strain gages to measure strain in the reinforcing bars.

III. HISTORICAL REVIEW

(a) Plain Concrete

The use of plain concrete for road surfaces dates back long before the beginning of the twentieth century. At the end of the nineteenth century plain concrete pavement was in existence both in Europe and the North American Continent. One of the earliest concrete pavements on record is that constructed in Inverness, Scotland in 1865. In North America there is a record of one which was constructed in Bellefontaine, Ohio as early as 1892. In Canada the earliest concrete pavement of which there is a record was that constructed in Toronto in 1902.

The early concrete pavements were laid in blocks ranging from 6 to 25 foot square with expansion joints ranging from $\frac{1}{4}$ inch to 1 inch between blocks (1)*.

The general practice until the late 1920's involved 6 inch unreinforced concrete slab with both expansion and contraction joints. Field performance and mathematical analysis of the stresses in concrete pavements under wheel loads made in the 1920's showed that greatest stresses existed at the corners and edges of concrete panels. This finding led to development of designs with thickened edges such as 9 inch to 7 inch to 9 inch, in which the slab was made 9 inches at the edges and 7 inches over the central portion. This type of design, however, was abandoned some years ago because of the increasing cost of preparing the base to take the slab of varying depth (1).

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* Refers to bibliography.

The present practice in plain unreinforced concrete pavement involves uniform slab thickness which varies from 7 to 10 inches in depth.

(b) Reinforced Concrete with Closely Spaced Joints

As a result of extensive research and experience in the field, reinforced concrete pavements came into use. These have increased in size to encompass 10 to 12 foot lane widths, lengths of 30 to 100 feet, the thickness of from 6 to 10 inches or more. Comparatively light reinforcing has been utilized as a means of tieing the cracks in the pavement together and to give the pavement some flexural strength.

The design of conventional reinforced concrete pavement with load transfer joints every 30 to 100 feet is based on the assumption that minor thermal cracking will occur between the joints, and that all deformations will take place at load transfer joints (2).

This form of construction, because of its increased resistance to damage, is superior to plain concrete, especially in regions where poor soils and low temperatures are encountered.

(c) Continuously Reinforced Concrete Without Joints

Although conventional reinforced pavement has given satisfactory service over the years, engineers connected with the road building industry felt that it was not the optimum that could be accomplished with reinforced concrete. Factors such as pumping, roughness and displacement at the joints, breaks and warping due to frost action and volumetric changes in the subsoil have become recognized as major deficiencies in the performance of the conventional reinforced pavement.

Several years ago it was suggested,on a theoretical basis, that if cracks which form were held tightly together, pavement cracking could be permitted to occur at any natural interval. However, sufficient reinforcement should be provided to prevent the cracks opening to the extent which would permit pavement pumping and cause extreme strains in the steel due to vehicle loads. In the continuously reinforced concrete pavement, emphasis is transferred from the stress consideration and is placed on the relation between the strain in the steel and the width of the crack opening.

The elimination of contraction and expansion joints and relative displacement at the cracks should give smoother riding qualities. Perhaps the most important advantage of such construction for the Province of Alberta could be the elimination of spring road bans.

Continuously reinforced concrete pavements have been constructed in the United States as experimental projects in New Jersey, California, Illinois, Indiana, Texas and Pennsylvania(2).

IV. OBJECTIVES

The objectives to be studied in this thesis may be stated as follows:

1. To determine the maximum strains in the reinforcing steel, taking into account the varying percentages of reinforcement and varying thicknesses of pavement.
2. To determine the effects of temperatures on the strains in the reinforcing steel.
3. To determine the behaviour of the pavement at a crack by measuring the crack width and the strains in the steel.
4. To determine strain in the reinforcing steel at points removed from the preformed crack.
5. To determine the thermal effect on the width of the cracks.

V. THEORY

Theoretically, the behaviour of a continuously reinforced concrete pavement is dependent upon three factors: The shrinkage of concrete; expansion and contraction caused by temperature; and strains induced by imposed external wheel loads.

Shortly after concrete is poured it tends to contract due to capillary forces. This mechanism is commonly referred to as "shrinkage". In reinforced concrete pavement, the restraints offered by the bonded steel and the subgrade establish net tensile forces in the slab. When this tensile force reaches the magnitude of the rupture strength of the concrete, a shrinkage crack forms.

The temperature mechanism of cracking for continuously reinforced concrete pavements is similar to shrinkage mechamism, except that the contraction of concrete is not caused by shrinkage but by the drop in temperature. For a given temperature drop, the total displacement of a slab resting on a subgrade will be less than for a free slab because of the subgrade restraint. Thus the magnitude of horizontal movement will depend not only on the coefficient of thermal expansion, but also on the friction which will be developed between the subgrade and pavement. With the drop in temperature the concrete will tend to contract. No restraint is offered by the steel whose coefficient of expansion or contraction is almost the same as that of concrete(3). However, shearing forces mobilized between the subgrade and the pavement will tend to prevent any movement of the slab, thus causing tensile stresses to develop in the concrete pavement. The magnitude of these stresses will depend on the temperature drop and the subgrade restraint.

The distribution of stress in the concrete will start from zero at the free end and build up to a fully restrained value at some distance from the free end. At a point some distance away from the free end, at which the total frictional force becomes larger than the potential tensile force of concrete, the slab will crack. It is assumed here that the steel takes no tension stress until the concrete cracks. This is a good assumption since the load taken by the steel just before the concrete cracks is small compared with that taken by the concrete slab.

Once the crack develops, all the load is picked up by the steel, thus providing continuity of the pavement. Any tensile stress that develops in the steel at cracks must occur in the immediate vicinity of the crack. As a result, the reinforcing steel spanning each crack must either maintain the strain within its elastic limit by losing bond with the surrounding concrete, or yield in tension.

Shrinkage and temperature induced straining are in operation to varying degrees of magnitude at all times. Initially, the shrinkage mechanism predominates, while at a later age, the temperature mechanism is the major one. Initially, all cracks are probably due to shrinkage. These cracks may well set the pattern of future behaviour (3).

VI. GENERAL DESCRIPTION OF THE TEST PROJECT AND CONSTRUCTION PROCEDURES

In the fall of 1958 the Alberta Department of Highways built 3 miles of proposed 4½ miles of concrete test road with two 12 foot lanes bound by 10 foot asphalt shoulders. The experimental strip, which is part of the Trans Canada Highway, extends for 4½ miles west of the Bow River Crossing (Plate 1). The dimensions and reinforcing in the sections are as follows:

(a) Continuously Reinforced Concrete Pavement

Section Type	Station From	Station To	Length in Feet	Thickness in Inches	Reinforcing Steel in %
B6-2	280 +03.0	302 + 07.5	2204.5	6	0.815
B6-1	302 + 07.5	321 + 79.5	1972.0	6	0.715
B7-1	321 + 79.5	348 + 24.5	2645.0	7	0.706
B7-2	348 + 24.5	374 + 72.5	2648.0	7	0.784

(b) Reinforced Concrete Pavement with Joints Spaced at 30 Feet

Section Type	Station From	Station To	Length in Feet	Thickness in Inches	Reinforcing Steel in %
A-8	187 + 93.0	223 + 03.0	3510.0	8	0.139
A-7	223 + 03.0	253 + 93.0	3090.0	7	0.159
A-6	253 + 93.0	280 + 03.0	2610.0	6	0.185

(c) Plain Concrete

8 inch non-reinforced concrete slab 5239 feet long with load transfer joints every 20 feet.

Transverse reinforcing consisting of $\frac{1}{2}$ inch round bars were spaced at 23" in sections A-6, A-7, and A-8 and at 30" in sections B7-1, B7-2, B6-1 and B6-2.

The construction of the pavement was started in the first week of September, 1958 and, because of freezing temperatures, had to be stopped two months later in the first week of November. Six sections were completed in the fall of 1958, namely: Section A-6, B6-1, B6-2, B7-1, B7-2 and Section C. Sections A-7 and A-8 will be completed in the spring of 1959.

Only sections A-6, B6-1, B6-2, B7-1 and B7-2 are discussed here. A full discussion on Section C is to be presented in thesis entitled "Experimental Concrete Pavements in Alberta" by K. Ellert (4).

The pavement was built on 4 inch granular base course throughout the length of the test road.

Continuously Reinforced Concrete Pavement

The total length of the continuously reinforced pavement, comprising of Sections B6-1, B6-2, B7-1 and B7-2, is 9,469 feet.

At both ends of the continuously reinforced section finger type steel expansion dams were built (Figures 1 and 2).

In Sections B6-1 and B6-2, the longitudinal reinforcement for each lane consisted of 14 and 16 No. 6 intermediate grade deformed steel bars resulting in 0.715% and 0.815% cross-section area of the pavement respectively. In Sections B7-1 and B7-2, longitudinal reinforcement for each lane consisted of 9 and 10 No. 8 intermediate grade deformed steel bars resulting in a 0.706% and 0.784% cross-section area of the pavement respectively.

The longitudinal reinforcing bars were placed and tied to $2\frac{1}{2}$ inch risers. The $\frac{1}{2}$ inch transverse bars were laid on top and tied at every point the transverse bar crossed the longitudinal bar (Figure 3).

Special gages were installed in ten locations to facilitate the measurement of temperature and longitudinal strain in the vicinity of transverse pavement cracks at an artificially induced plane of weakness.

Bakelite type "SR-4" strain gages were attached to the surface of four of the longitudinal reinforcing bars at each location. These gages were located at the preformed cracks and at distances ranging from 18 to 40 diameters away from the crack.

Thermocouples were placed at the same locations in the pavement to indicate local temperatures, and also to permit a study of the effects of vertical temperature gradation in the concrete slab.

Steel gage points were installed on both sides of the plane of weakness near the edges of the pavement and near the centre line to allow the measurement of crack opening.

The electrical leads from gages within the pavement were carried in the ground below the base course to a plywood terminal box located on the sideslope of the pavement (Figure 4 and Plate 1).

Strain and temperature readings were taken within eight hours after concrete was placed at the sections where gages were installed. The initial gage readings provided a base for all subsequent readings.

During the first 10 days, readings were taken at least once a day to determine initial behaviour of the slab. Subsequent readings were taken once every 7 days for the first month.

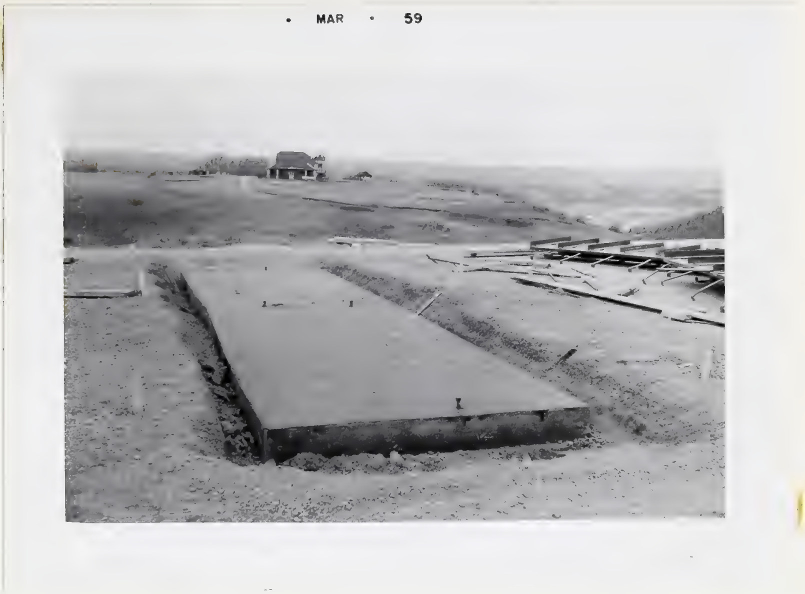

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Figure 1 Base Slab for Expansion Dam

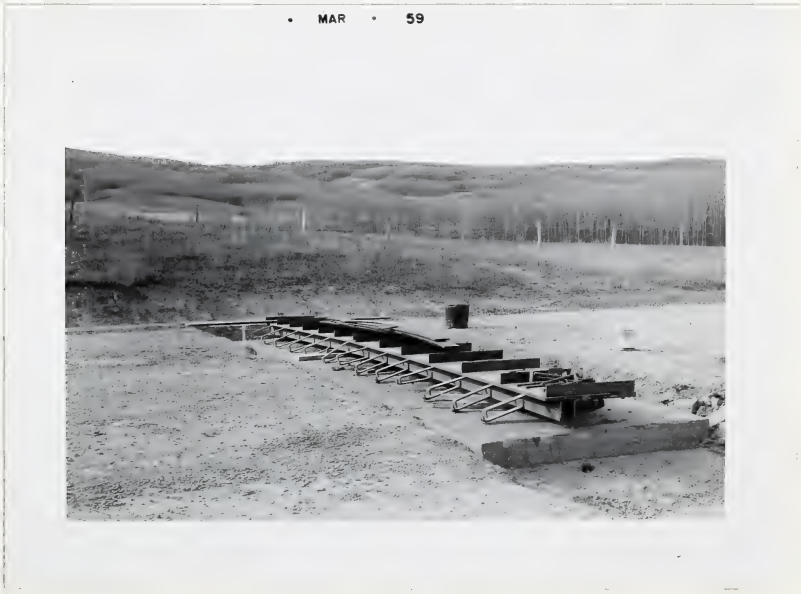

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Figure 2 Expansion Dam Installation

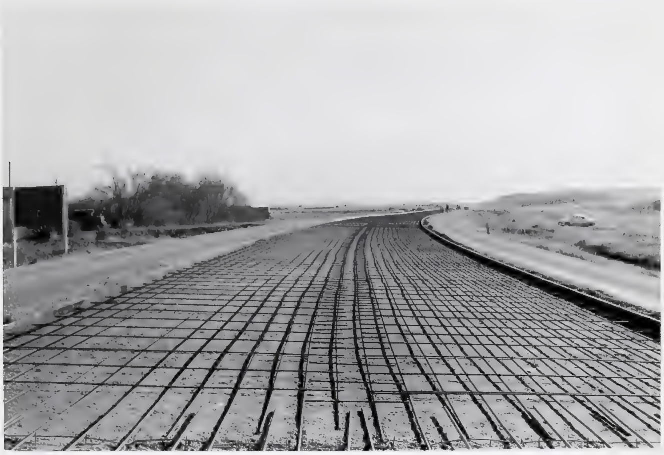

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Figure 3 Placement of Reinforcement in Continuously reinforced Pavement

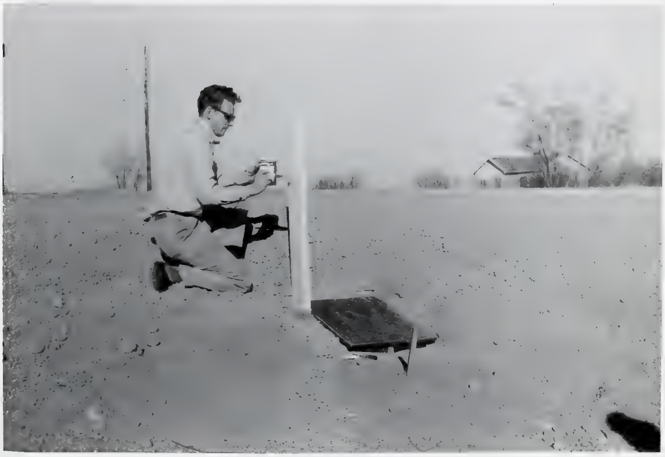

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Figure 4 Terminal Box in Place

VII. INSTRUMENTATION

Altogether forty-eight longitudinal reinforcing bars were gaged to measure the strains at the instigated cracks and also at distances from 12 to 40 diameters on each side of the crack.

Surface Preparation

To obtain a smooth surface suitable for attaching the "SR-4" gages, it was necessary to remove the deformations from the deformed bars. The deformations were filed off while the final polished surface was obtained using different grades of emergy cloth (Figure 5). The removal of the deformations and surface polishing caused reduction of cross-sectional area by about 5%.

Type "AB-3" wire resistance strain gages were attached to the bars as strain transducers (Plate 2). They were arranged to allow measurement of direct strain.

The process of attaching the "SR-4" bakelite gages to steel surface involves baking at temperatures ranging from 175°F. to 350°F. to cure the cementing resins. In order to produce a correct amount of heat and fascilitate a systematic method of curing a number of gages, an oven housing eight bars was designed (Figure 6). Special clamps were fabricated and used to apply the required pressure to assure a good bond between the gages and the steel (Figure 7).

After all the gages were attached, completely wired, waterproofed and checked for stability, the bars were placed in wooden racks and shipped to the test site (Figure 8).

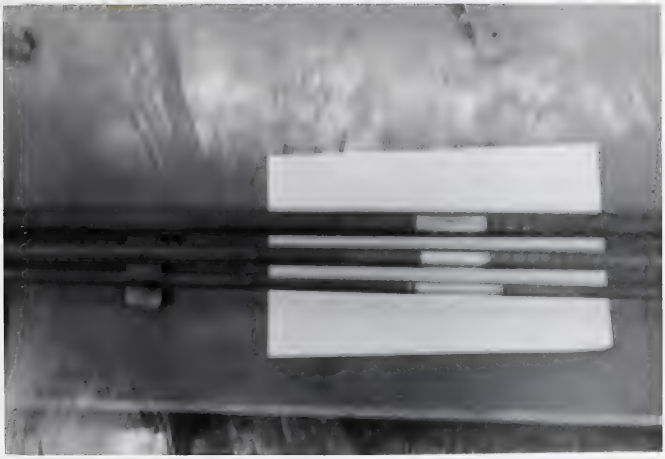

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Figure 5 Surface Preparation

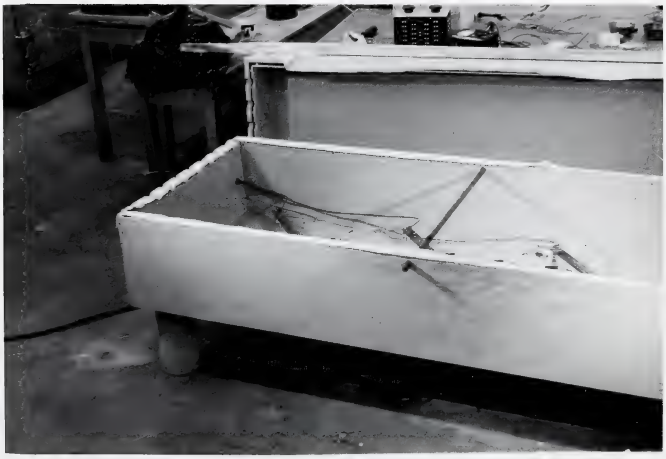

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Figure 6 Oven Used in Curing Cementing Resins

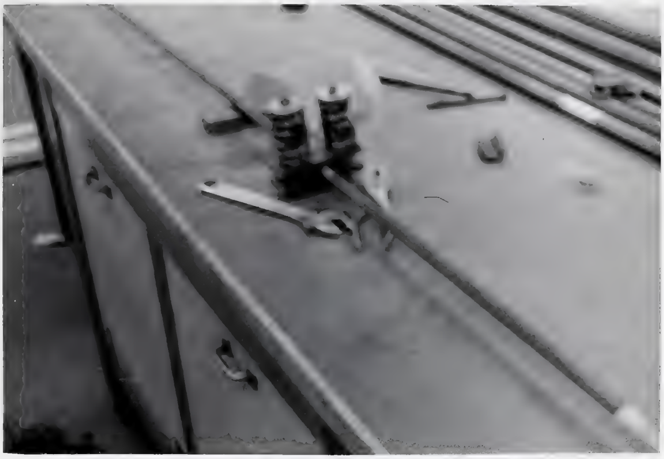

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Figure 7 Application of Pressure to Assure Good Bond Between "SR-4" Gage and Reinforcing Steel

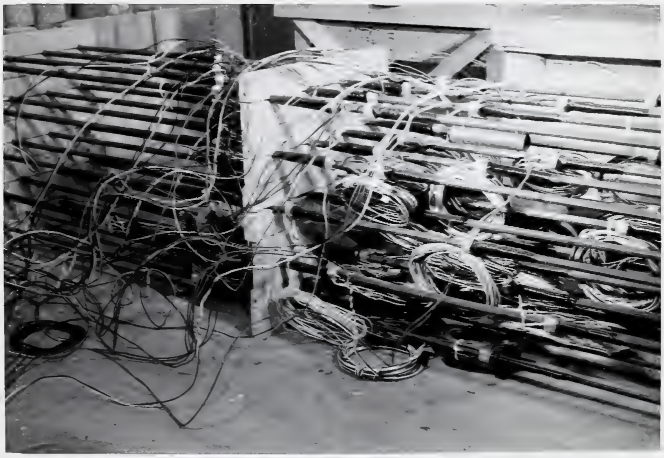

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Figure 8 Prepared Bars Ready for Shipment

The alloy wire used in "SR-4" gages is sensitive to temperature as well as strain. While this temperature sensitivity is very small compared with that of strain, it must be considered in cases where accurate measurements are to be made under varying temperature conditions(5).

The four-arm bridge circuit used in most electrical strain reading instruments provides a means for correction of errors due to temperature changes. This involves the use of temperature compensating gages that must be subjected to all of the conditions of the active gage except strain. When this gage,commonly known as a "dummy", and the strain measuring gage, known as "active gage", comprise adjacent arms of a four-arm bridge circuit, only the strains in the active gage influence the output of the bridge.

Two temperature-compensating gages were prepared for use at each test location (Figure 9). A strain gage was attached to a bar 4 inches in length and of the same type of steel as used in a given test location. After the gage was attached, wired, waterproofed and checked for stability, the unit was inserted into a pipe 6 inches in length and sealed with petrolastic asphalt (Figure 10). This device, when placed in concrete pavement, would be subjected to the same temperature conditions as the reinforcing steel, but would not be affected by external strain producing loads.

As the paving operations approached the test location, the prepared bars and thermocouples were set in place (Figure 11). At each test location four bars were removed and replaced with prepared bars. All the lead wires at the test panel were carried into the terminal box located on the side-slope of the road.

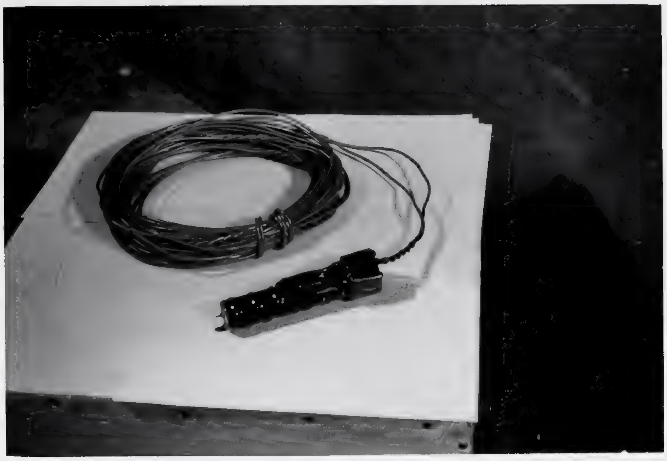

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Figure 9 Waterproofing of Temperature Compensating Unit

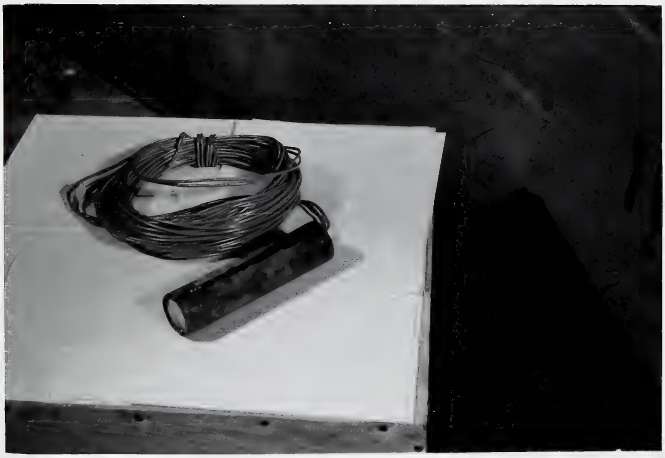

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Figure 10 Temperature Compensating Unit Ready for Installation

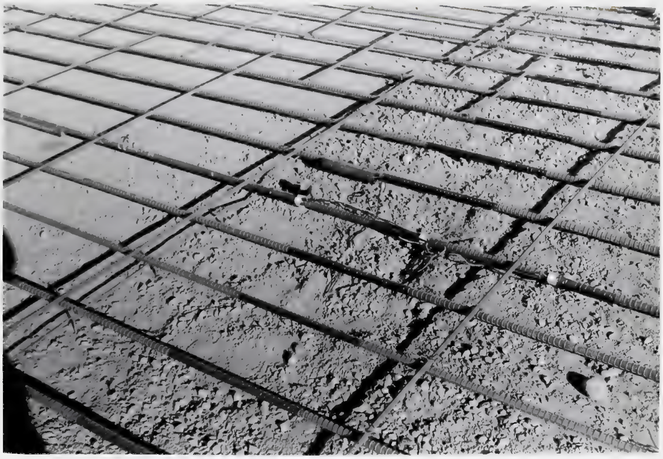

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Figure 11 Prepared Bars in Place

A "Demec" strain gage, with an 8 inch gage length and a range of 0.10 inches, was used to measure the width of the instigated crack at each test section. An invar calibration bar provided a standard gage reference for measurements that would be made at regular intervals for an extended period of time.

Two steel plugs, $\frac{1}{2}$ inch in diameter and 3 inches long, provided receptacles for the conic points of the gage. The steel plugs were fabricated of a No. 4 reinforcing bar by simply cutting the reinforcing bar into 3 inch lengths, machining one end and drilling a hole 1/64 inch in diameter and 1/32 inch deep. After the finishing operations these plugs were placed in concrete pavement at chosen locations, approximately 8 inches apart. After the initial set of concrete, the "zero" measurements were made and recorded.

Several types of temperature transducers were considered for use in the measurement of temperature at selected positions within the pavement structure.

Economic considerations and time of delivery indicated the use of copper-constantan. The end of both copper and constantan wire was bared for about $1\frac{1}{2}$ inches. The ends of these wires were twisted into a loop and soldered together. After it was determined experimentally that calibration curve for all practical purposes was a straight line, the soldered end forming what is known as "warm junction" was waterproofed by dipping several times in neoprene.

Four to five temperature gages were installed in the pavement in the predetermined locations. Three gages were placed

vertically, one above the other, 1 inch up from the bottom of the slab, at a longitudinal centreline of the pavement, and 1 inch below the pavement surface.

VIII. INTERPRETATION OF RESULTS

A. Continuously Reinforced Concrete Pavement

1. Section Type B7*-2

The reinforced concrete pavement, Type B7-2, 2,648 feet in length, consists of a seven inch slab reinforced with No. 8 intermediate grade, deformed steel bars, comprising 0.784% of the cross-section area of the pavement (for details see Plate 4).

Two test sections, referred to from here on as "Location I and Location II", were located at stations 364+00 and 357+00 respectively.

(a) Location I

Concrete, in the test section located at station 364+00, was poured at 9 a.m. on September 30, 1958. The first strain gage readings were taken about three hours after the finishing operations, at which time the air temperature was 60°F. Subsequent readings and strain calculations revealed that using the strain readings taken immediately after the finishing operation gave questionable results, so readings taken $8\frac{1}{2}$ hours after the concrete was placed were used as the basis for strain calculations for all subsequent gage readings.

Two "SR-4" strain gages were attached at each gage point, one on each side of the horizontal diameter of the reinforcing steel. Strains at each gage point were averaged and

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* "B" refers to continuously reinforced concrete strip.
"7" refers to the slab thickness.

plotted against time elapsed after construction in days. (For gage position, see Plate 1-12.)

Curves in Plate 1-1 represent the strain history at the instigated crack for the first two weeks after placing of concrete in the test section. Curves in Plate 1-2 represent the strain record at the instigated crack for sixty-six days after construction. Subsequent strain readings that were taken 113 days and 133 days after construction indicate that the reinforcing steel spanning the instigated crack had strained far beyond its yield point.

During the first four days after construction, when the average slab temperature was between 60 and 70°F., maximum compressive strains of 120 micro inches/inch were recorded. After four days when the slab temperature dropped below 60°F., the strains in the steel increased indicating tension. Readings taken 6.3 days after construction at a slab temperature of 52°F indicate that the slab had cracked at the plane of weakness, and tension strains in the steel of 350 micro inches/inch were recorded. Curves in Plates 1-1 and 1-2 indicate that steel in the south lane of the pavement was affected by temperature change to a greater degree than in the north lane. In the early life of the pavement higher compressive strains have been recorded in the south lane, and when a crack developed along the plane of weakness, the steel in the south lane was subjected to much higher tensile strains.

Readings taken 27 days after construction indicated that steel in the south lane had strained to 700 micro inches/inch tension at the crack, and that in the north lane to 225 micro inches/inch compression. Average crack width in the south lane at the time of strain readings was 0.028 inches while in

the north lane the average crack width was 0.032 inches (Plate 1-7). The average slab temperature recorded at the time of readings was 34°F. An explanation of this phenomenon will be attempted when the discussion of the strain pattern at the gage points away from the crack is presented.

The maximum elastic tension strains in the steel spanning the crack were measured on November 28, 1958, when the average slab temperature was $+1^{\circ}$F. The reinforcing bars at the crack in the south lane were strained to 1,675 micro inches/inch and in the north lane to 1,250 micro inches/inch. Readings taken on December 5th of the same year, or sixty-six days after construction when the slab temperature was about 2°F., indicate somewhat lower strains in the bars spanning the crack.

Strain Pattern at Gage Points Away from the Crack

It has been pointed out that the strain history at the instigated crack is quite different in the two lanes of the pavement. Due to this dissimilarity, discussion of the strain pattern at gage points away from the plane of weakness may best be presented separately.

South Lane

The curves in Plates 1-3 and 1-4 represent the strain history in the reinforcing steel at gage points 16 to 27 inches away from the crack.

The magnitude of the strain in the reinforcing steel at the crack stayed approximately equal as long as the strains remained below the yield point.

After the bars yielded in tension, the strain at gage points 5-6 and 11-12 reached 1,400 micro inches/inch, while at gage points 1-2 and 7-8 strains of 380 and 700 micro inches/inch respectively were measured.

The development of this unusual strain pattern at gage points on each side of the instigated crack may best be explained by an increased loss of bond between the reinforcing bars and concrete west of the crack (Plate 1-8).

North Lane

The strain pattern in the north lane at the gage points away from the instigated crack was very similar to that in the south lane for the first 9 days after construction (Plate 1-3 and 1-5). Measurements taken 13 days after construction indicate large compression strains both at the instigated crack and at gage points away from this crack. A similar strain occurrence took place 20 and 27 days after construction. No definite explanation is available. It should be noted that a truck drove over one day's pour when the concrete slab was from 12 to 18 hours old, leaving deep tracks in the slab. These tracks were made in the north lane and in the vicinity of the prepared bars. The damage was corrected by the contractor the same day by filling the tire tracks with freshly mixed concrete. Additional repair work on these tire tracks was carried out about two weeks later.

This occurrence may account for this rather unique strain pattern at gage points, both at the instigated crack and away from it. No other explanation is available at the present time.

Considering the fact that the average width of the instigated crack in the north lane was 0.0325 inches when the strain

measurements indicated compression in the steel at the crack of 250 micro inches/inch, it seemed reasonable to assume that these strain measurements were unrealistic and incorrect.

The close relationship between strain in the reinforcing steel, crack width, and slab temperature is shown in Plate 1-2.

Curves in Plates 1-9, 1-10, and 1-11 indicate that the definite relationships existed between strain in the reinforcing steel and crack width, temperature and crack width, temperature and strain, when strain in the reinforcing bars spanning the crack remained within elastic range.

The above relationships ceased to exist after the reinforcing steel yielded in tension. It may be observed in Plate 1-10 that after the reinforcing steel yielded in tension the width of the instigated crack was wider for a given temperature.

No definite relationship seems to have existed between strain in the reinforcing steel and the crack width when strain in the steel was in the low elastic range. However, when strain in the reinforcing steel was in the medium to high elastic range, the strain in the steel increased in proportion to the increase in the crack width (Plate 1-9).

The temperature-crack width curve in Plate 1-10 indicates that the width of the instigated crack increased in proportion to the drop in temperature after sub-freezing temperature cycle started.

The relationship between strain in the reinforcing steel and the slab temperature is shown in Plate 1-11. It is evident that in the elastic range the strain in the reinforcing

steel increased in proportion to the drop in temperature.

During the early pavement life after the crack developed at the plane of weakness, constant temperature cycling prevented the formation of the adhesive bond between the steel and the concrete, and only the mechanical bond was developed at the extreme limits of differential movement between the concrete and the deformations on the reinforcing bar. The range of the differential movement deminished as the strain in the reinforcing steel at the crack increased, and as the distance from the crack became greater (Plate 1-11).

Conclusions

Loss of bond between the reinforcing bars and the concrete extended to a point about 16 bar diameters from the crack when strain in the reinforcing steel was in the elastic range. Additional bond loss took place after the reinforcing bars yielded in tension.

The reinforcing bars yielded in tension at the instigated crack when the slab temperature dropped below -20°F. If reinforcing steel with a yield point strain of about 2,500 micro inches/inch had been used, it appears probable that no yielding would have taken place at slab temperature as low as -40°F.

When the reinforcing bars started to yield at the slab temperature of -20°F., the width of the instigated crack probably increased to 0.06 inches. Assuming no yielding of the reinforcing steel, the instigated crack would have likely opened up to 0.07 inches at -40°F. unless additional cracks were forned.

It is of interest to note that the strain of the re-

inforcing steel crossing the instigated crack remained within the range of "SR-4" bakelite gages (15,000 to 20,000 micro inches/inch).

STRAIN TIME CURVES

SECTION TYPE B7-2 LOCATION I STATION 364+00

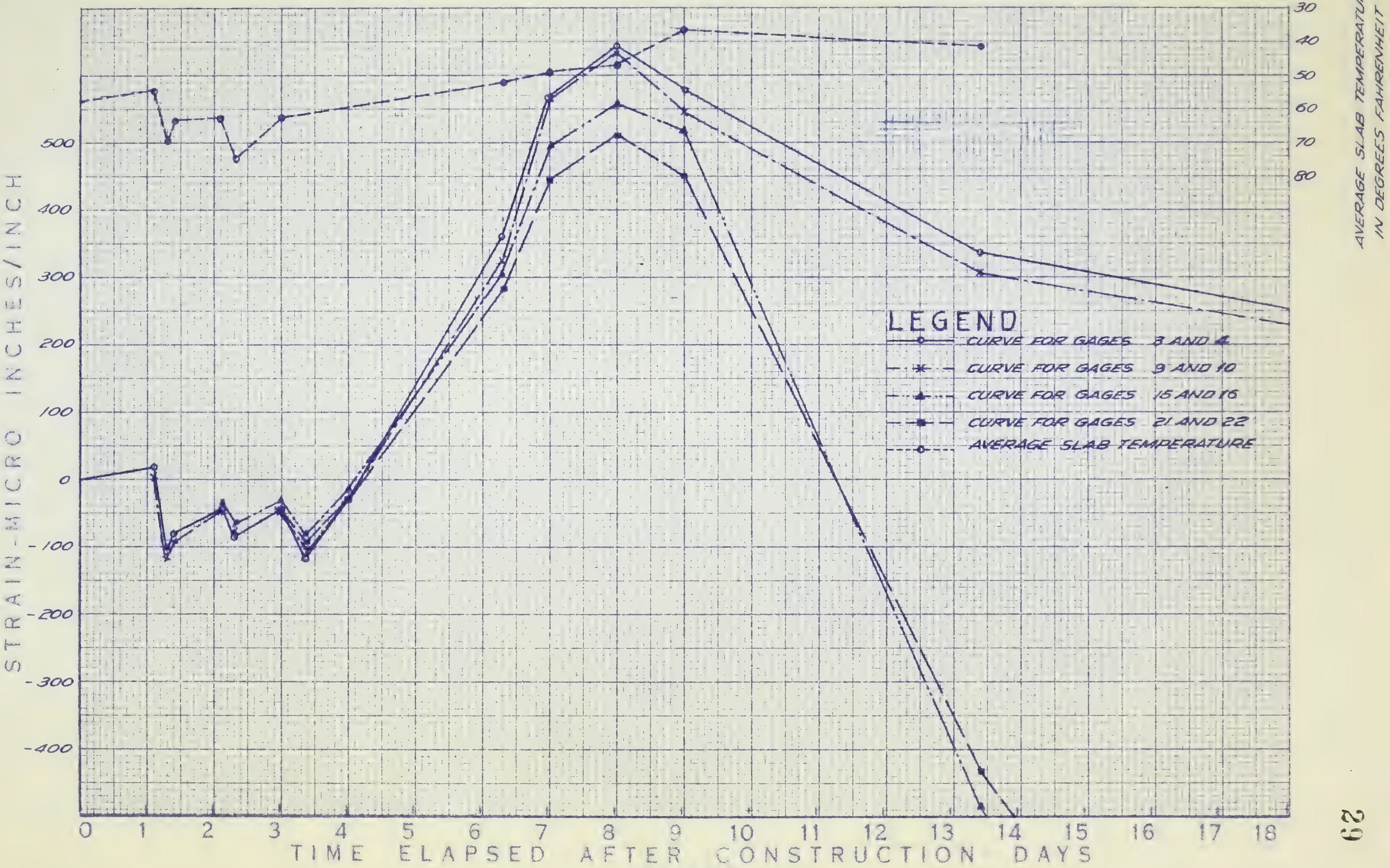


PLATE 1-1

STRAIN - TIME CURVES

SECTION TYPE B7-2 LOCATION I STATION 364+00

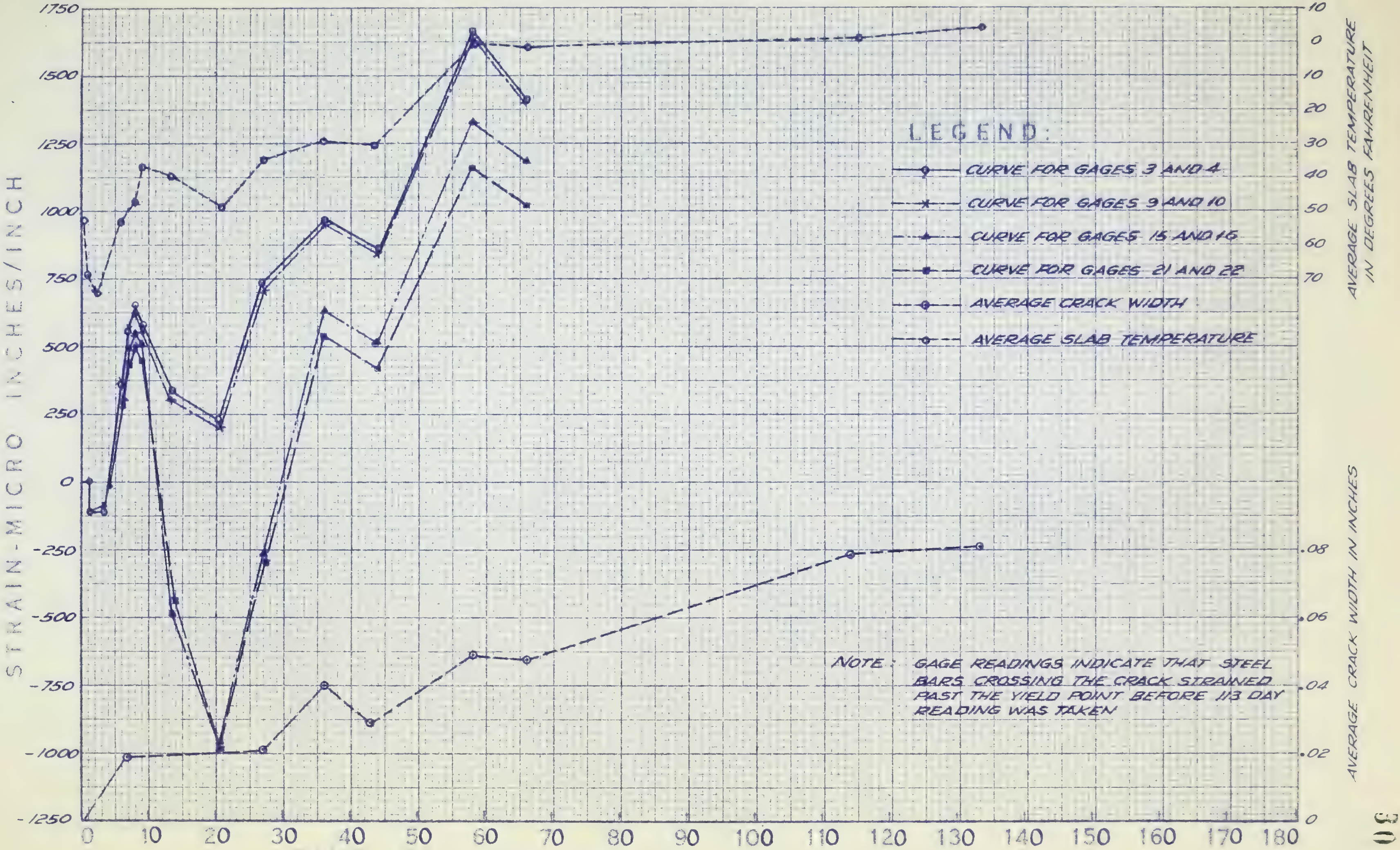


PLATE 1-2

STRAIN TIME CURVES

SECTION TYPE *B7-2* LOCATION *I* STATION *364+00*

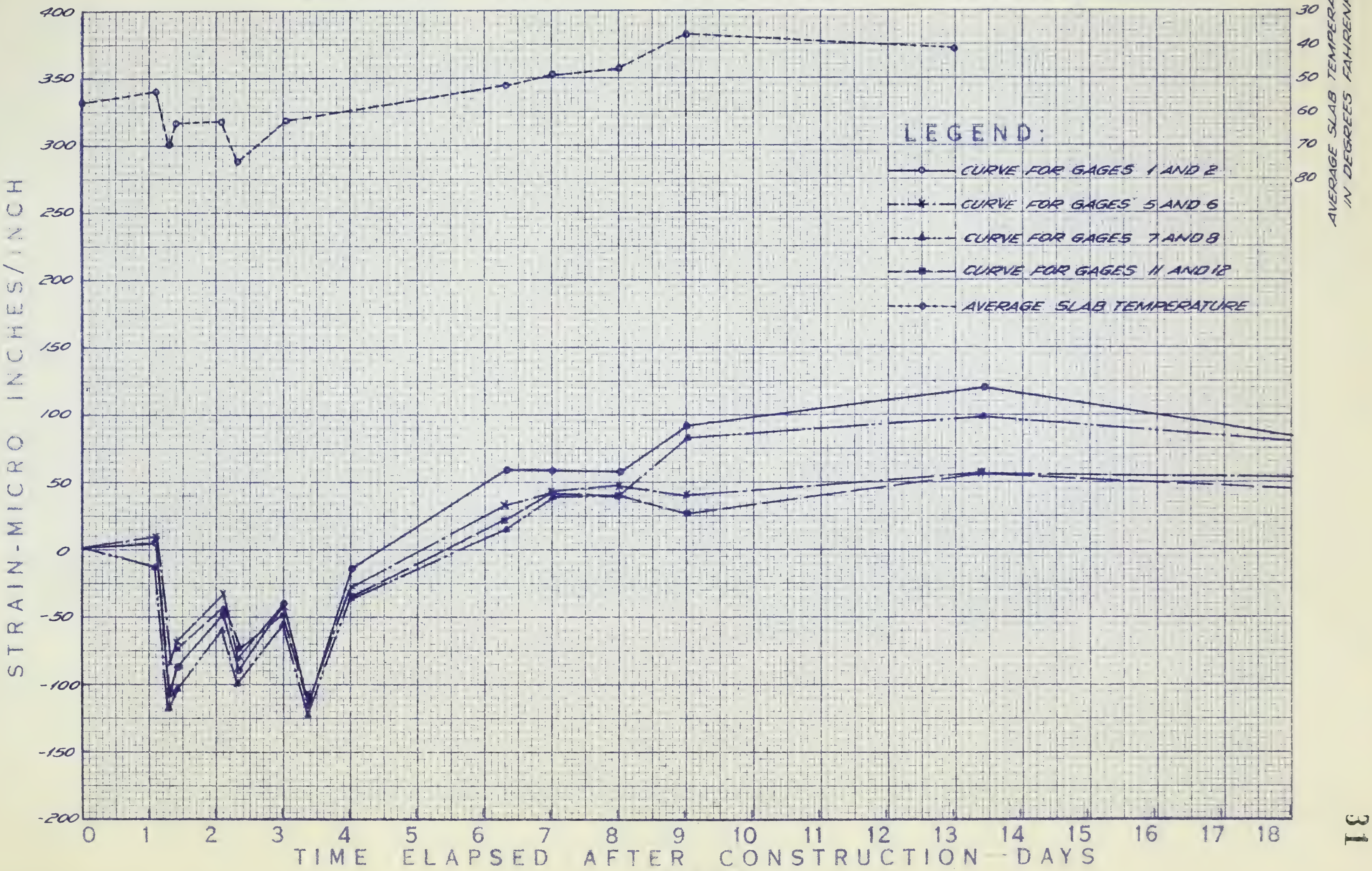
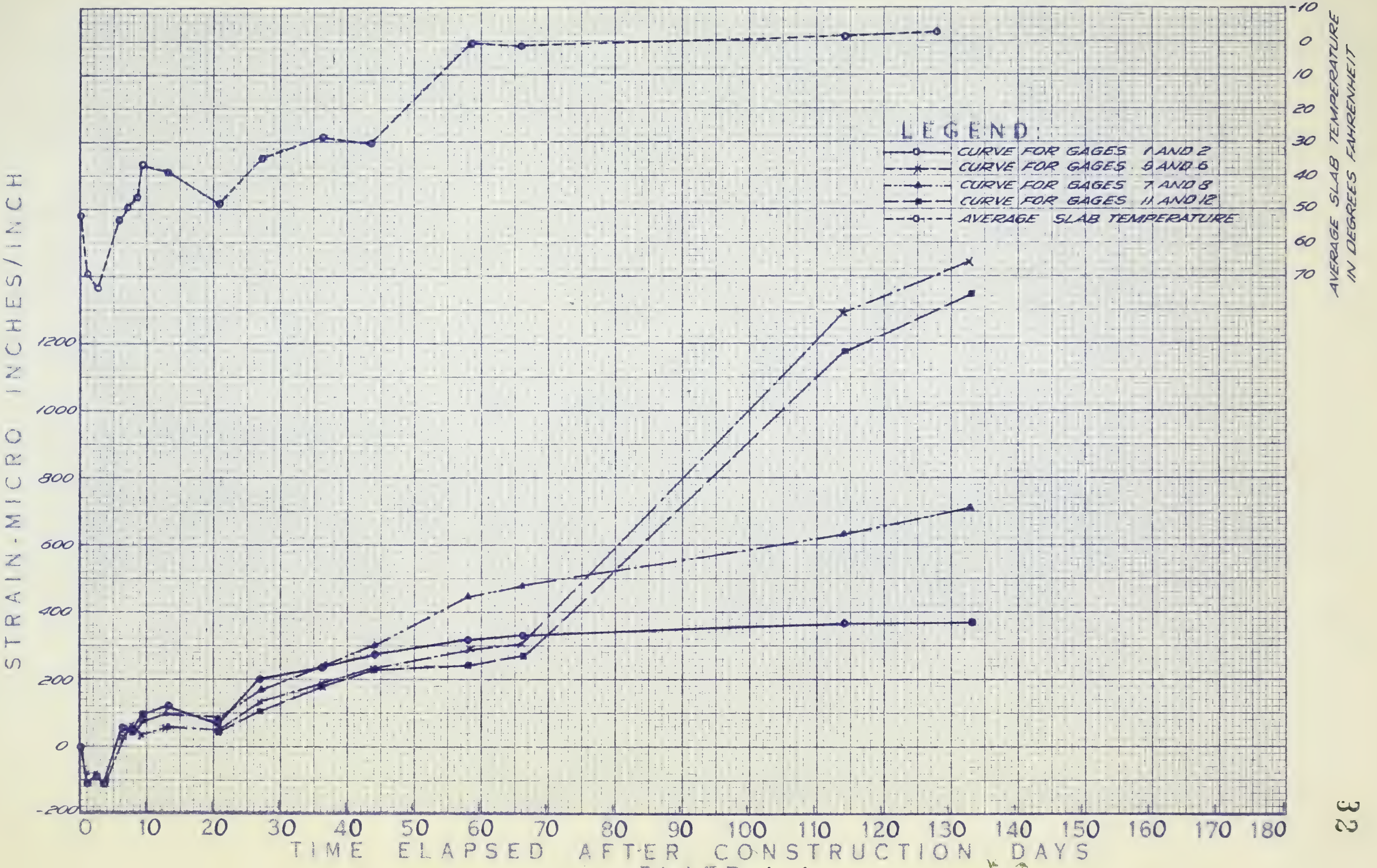


PLATE *1-3*

STRAIN TIME CURVES

SECTION TYPE B7-2 LOCATION I STATION 364+00



PLATE

STRAIN TIME CURVES

SECTION TYPE B7-2 LOCATION I STATION 364+00

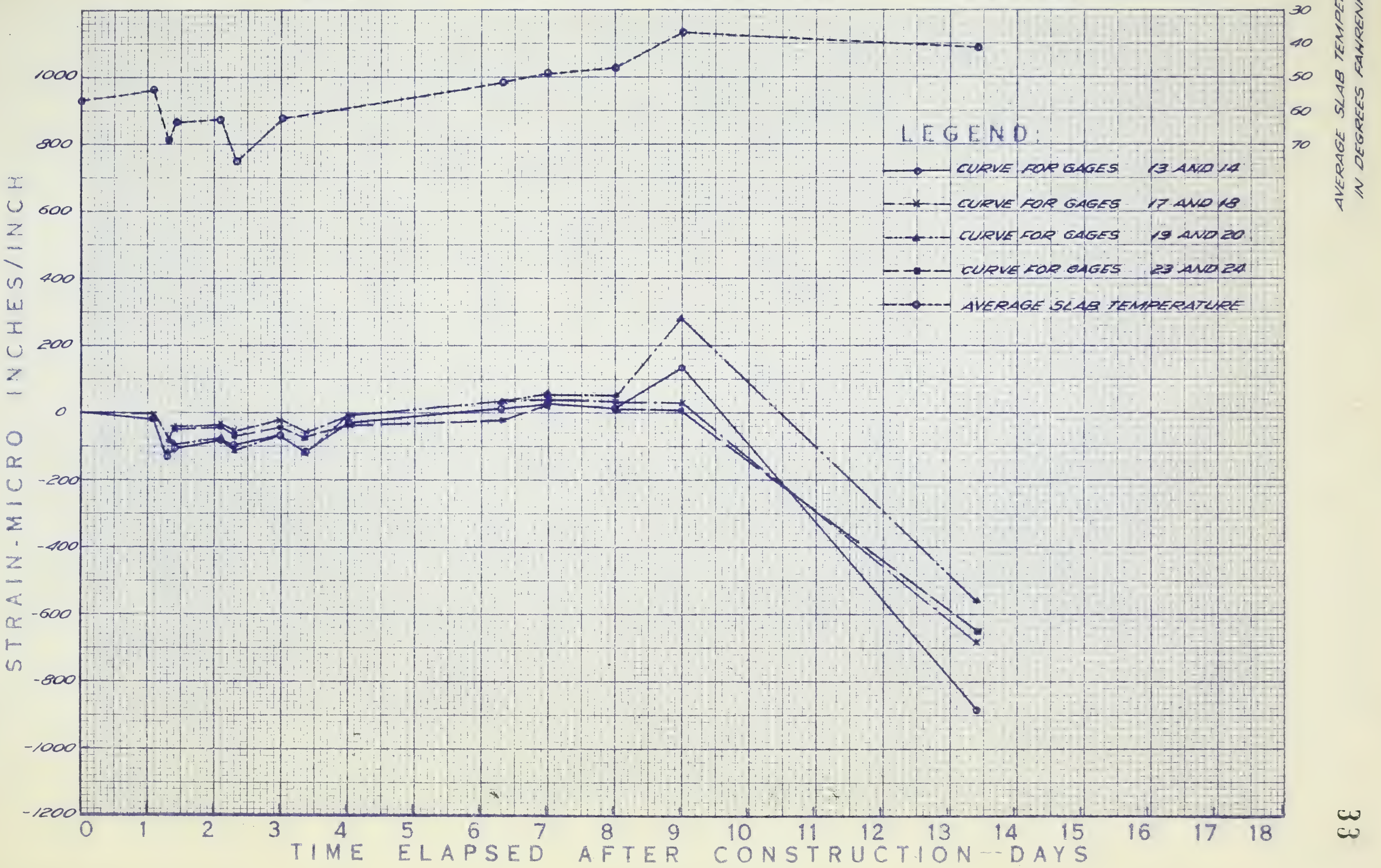


PLATE 1-5

STRAIN-TIME CURVES

SECTION TYPE B7-2 LOCATION I STATION 364+00

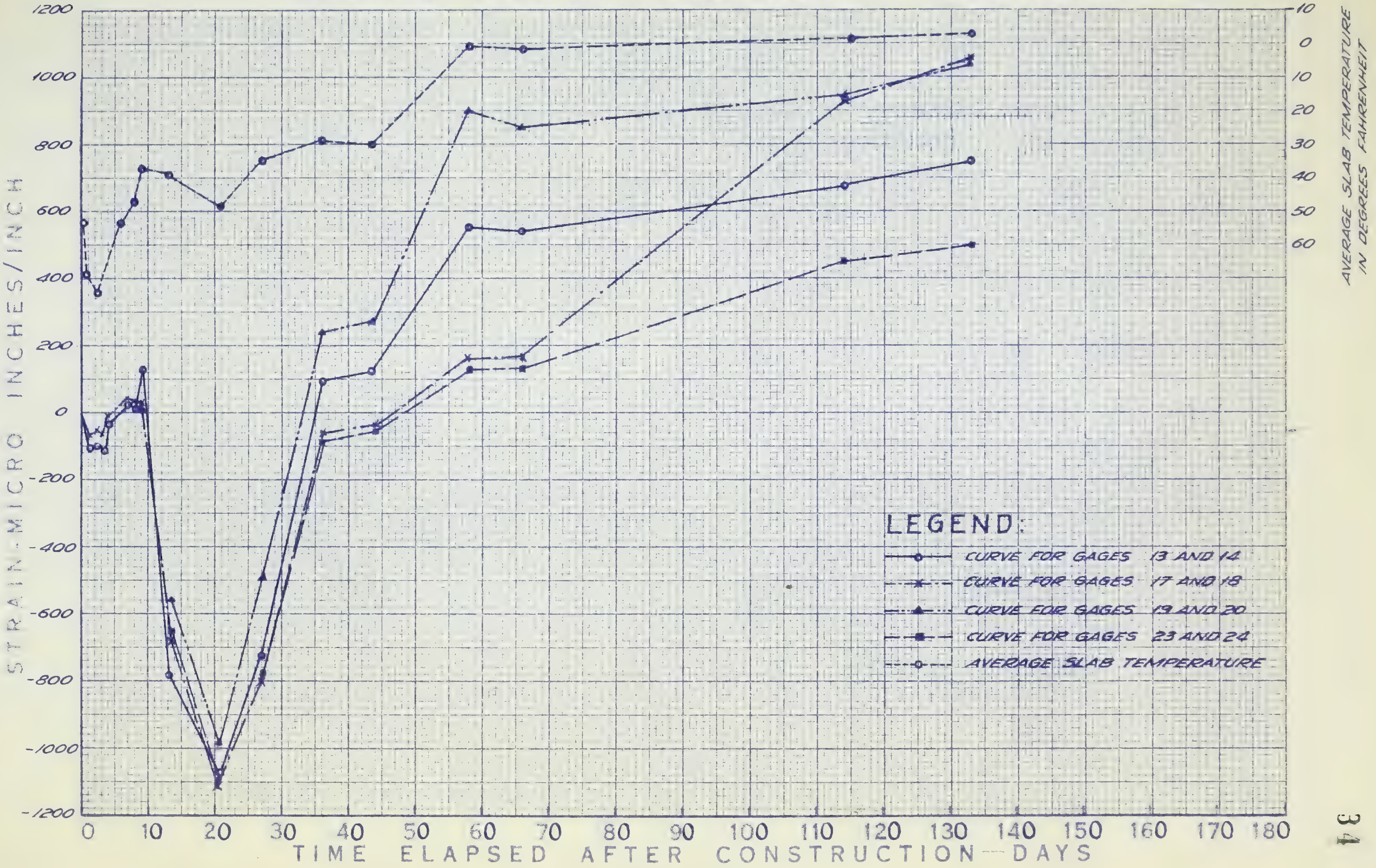


PLATE 1-6

CRACK WIDTH - TIME CURVES

SECTION TYPE B7-2 LOCATION I STATION 364+00

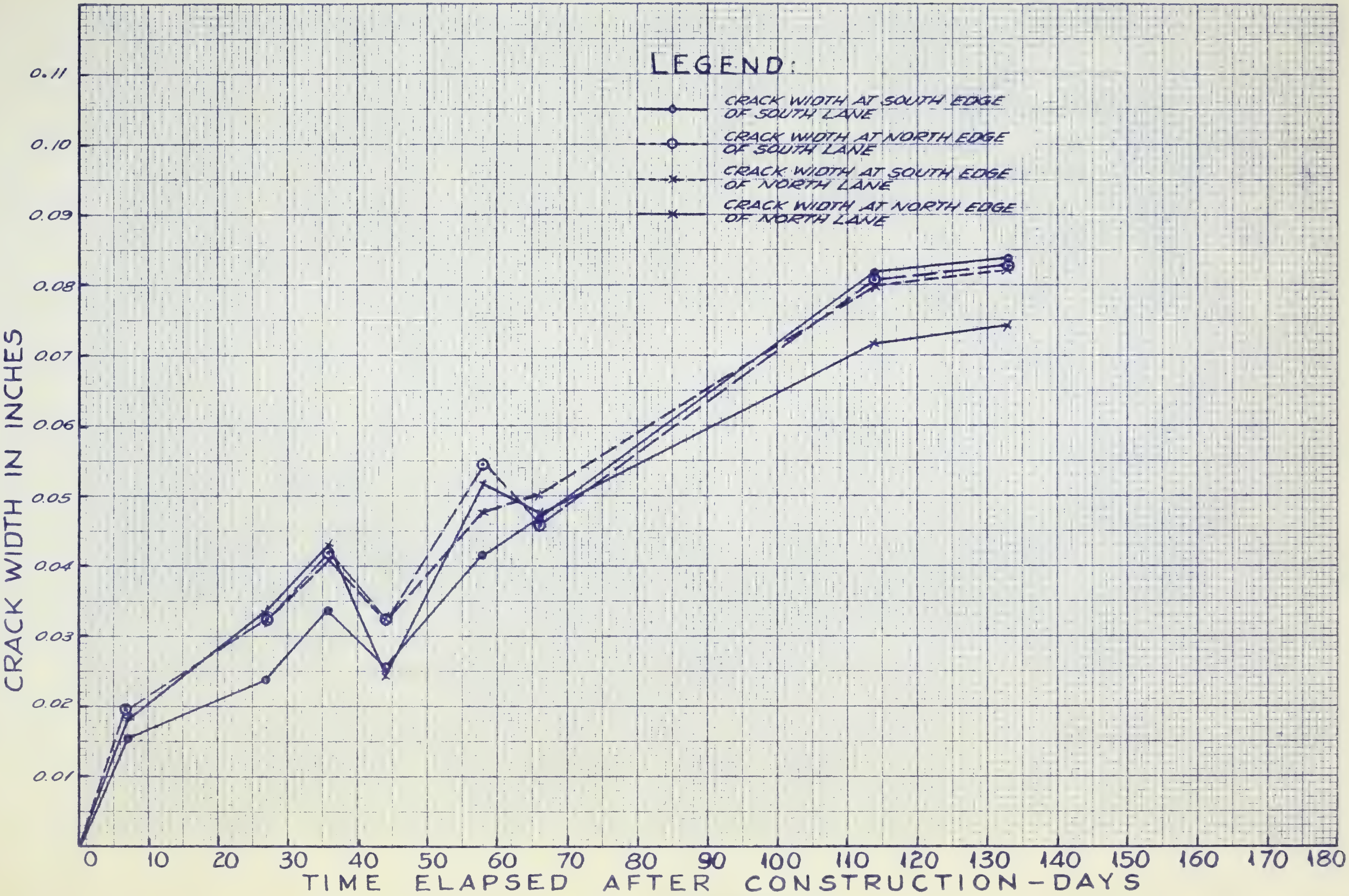
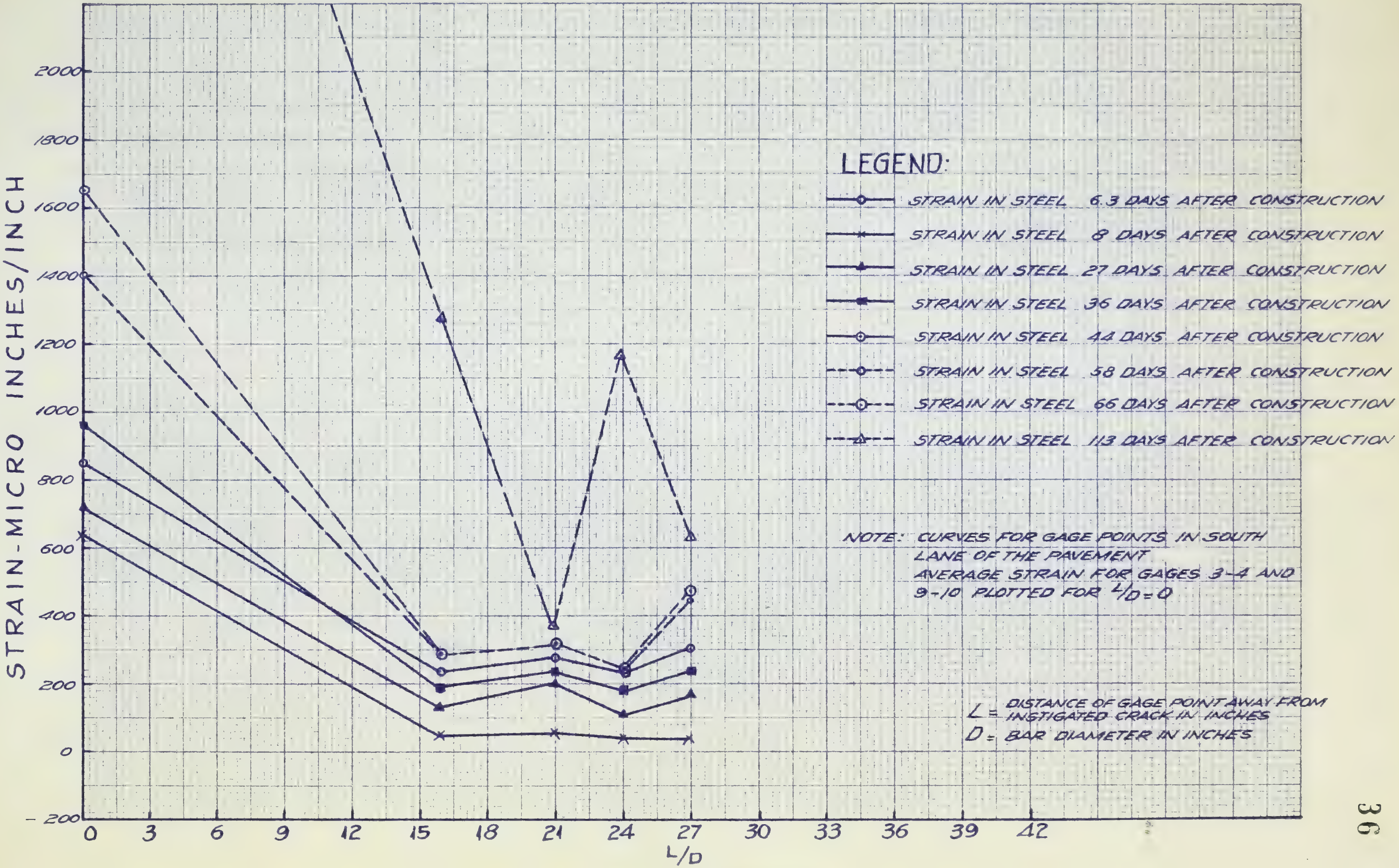


PLATE 1-7

STRAIN TRANSFER DISTRIBUTION CURVES

SECTION TYPE B7-2 LOCATION I STATION 364+00



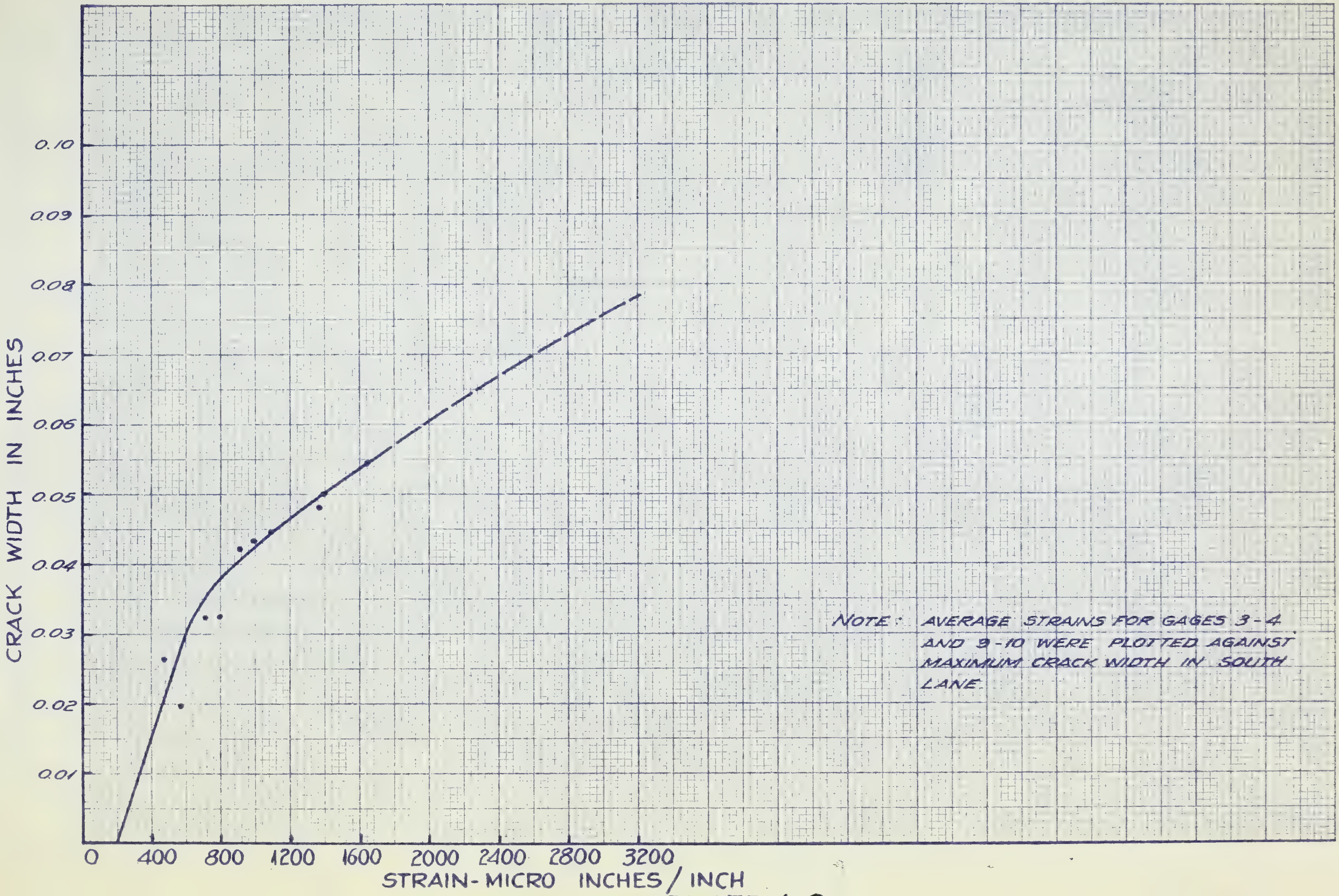
NOTE: CURVES FOR GAGE POINTS IN SOUTH LANE OF THE PAVEMENT
AVERAGE STRAIN FOR GAGES 3-4 AND 9-10 PLOTTED FOR L/D = 0

L = DISTANCE OF GAGE POINT AWAY FROM INSTIGATED CRACK IN INCHES
D = BAR DIAMETER IN INCHES

PLATE 1-8

STEEL STRAIN - CRACK WIDTH CURVE

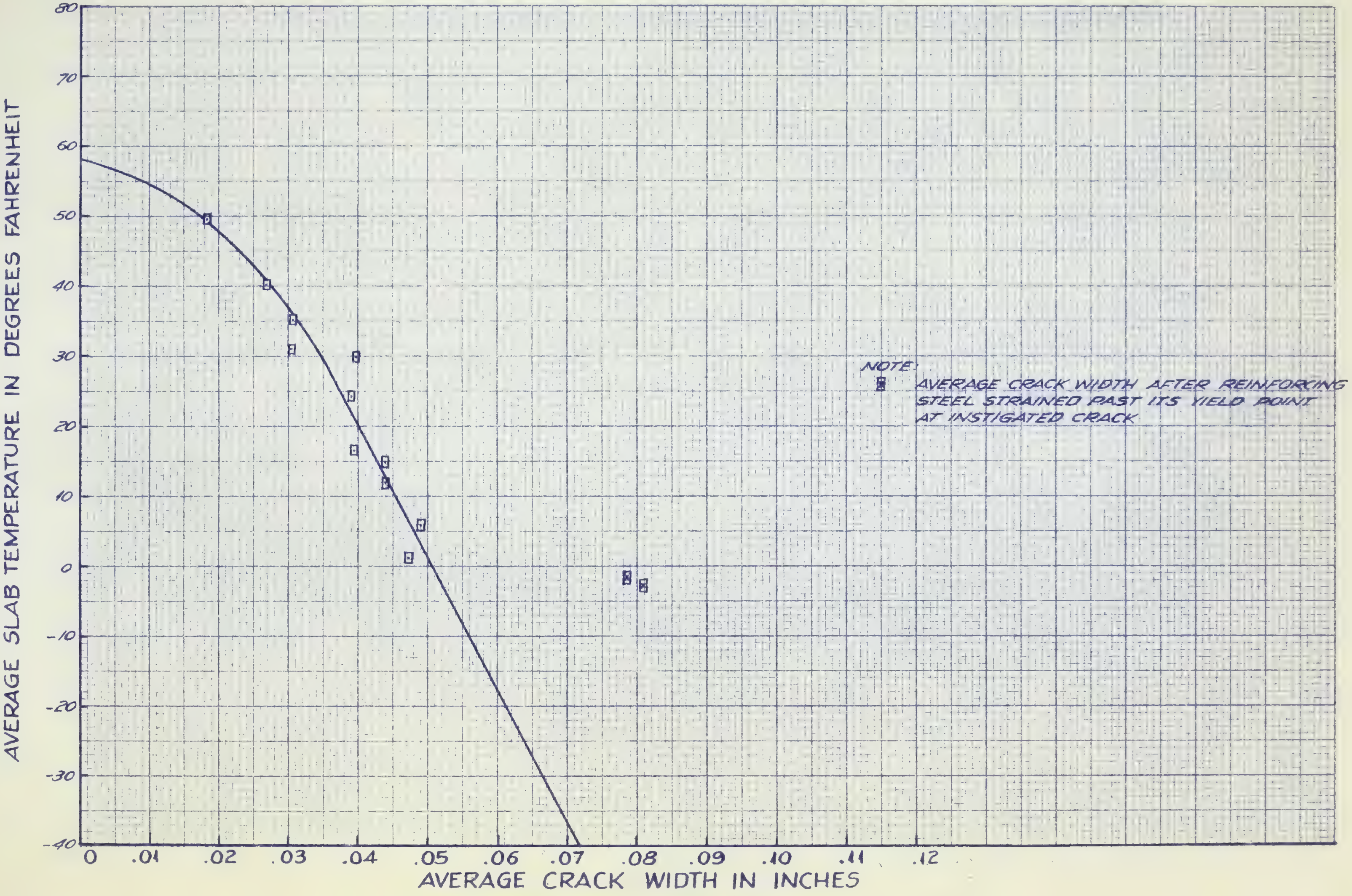
SECTION TYPE B7-2 LOCATION I STATION 364+00



NOTE: AVERAGE STRAINS FOR GAGES 3-4 AND 9-10 WERE PLOTTED AGAINST MAXIMUM CRACK WIDTH IN SOUTH LANE.

SLAB TEMPERATURE - CRACK WIDTH CURVE

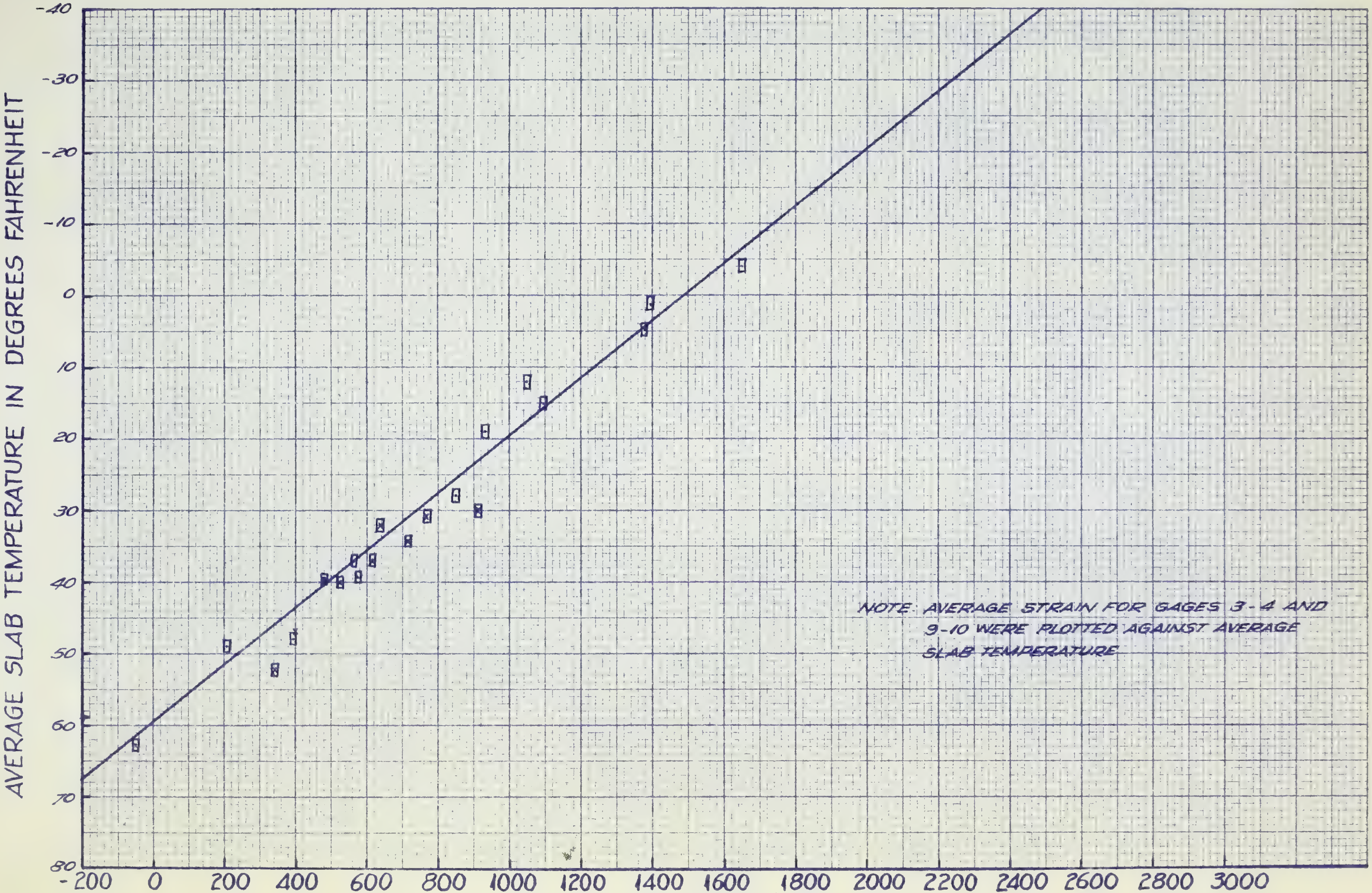
SECTION TYPE B7-2 LOCATION I STATION 364+00



NOTE:
⊠ AVERAGE CRACK WIDTH AFTER REINFORCING STEEL STRAINED PAST ITS YIELD POINT AT INSTIGATED CRACK

STRAIN - TEMPERATURE CURVE

SECTION TYPE B7-2 LOCATION I STATION 364+00



NOTE: AVERAGE STRAIN FOR GAGES 3-4 AND 9-10 WERE PLOTTED AGAINST AVERAGE SLAB TEMPERATURE

PLATE 1-11

SECTION TYPE B7-2

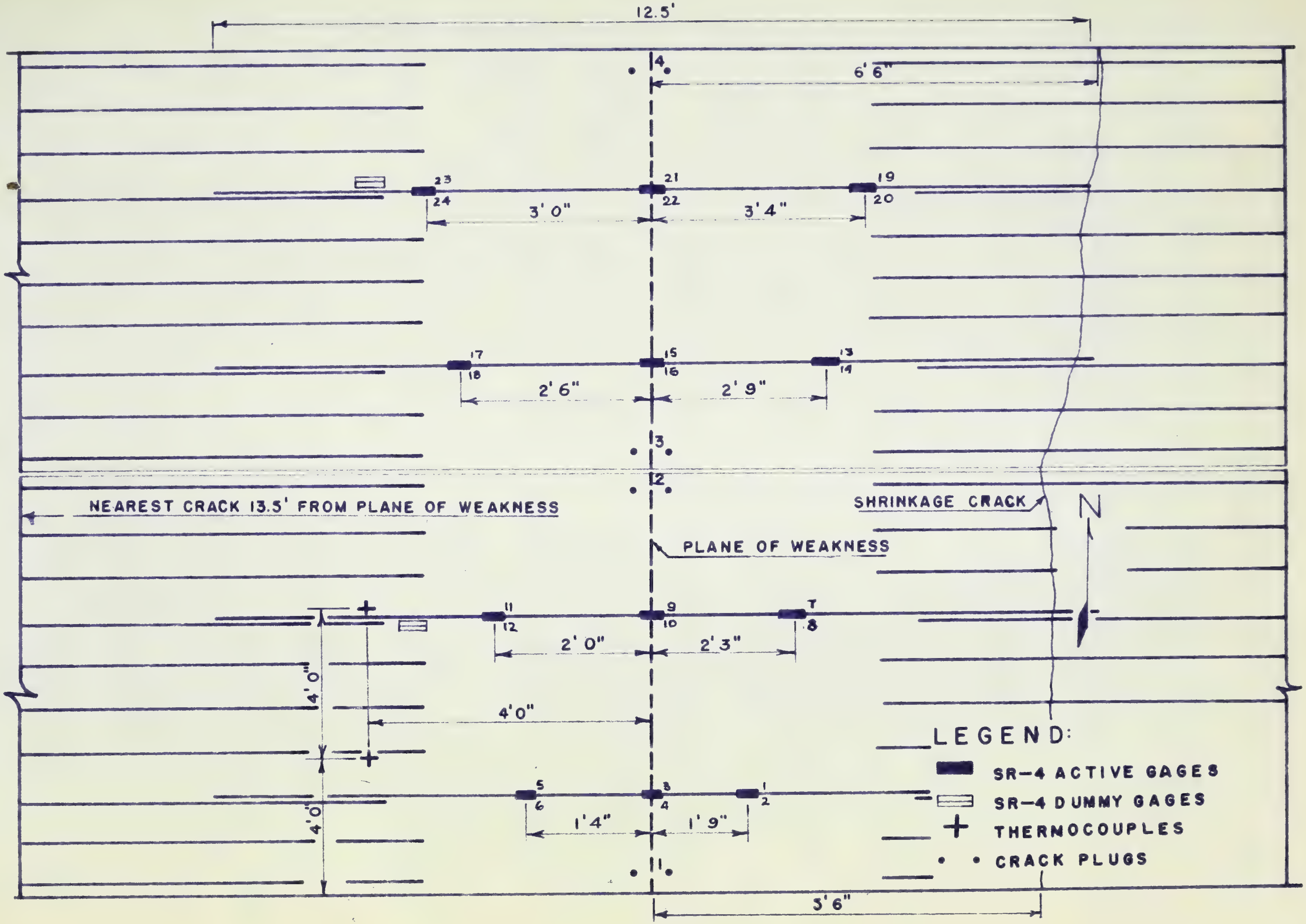


PLATE 1-12

(b) Location II

Concrete in the test section located at station 357+00 was placed at 11:00 a.m. on October 1st, 1958. First strain gage readings were taken about four hours after the finishing operation. These readings served as the basis for strain calculations for all subsequent strain measurements.

Separate strain-time curves for gages 3-4, 9-10, 15-16 and 21-22, located at the instigated crack have been plotted. These curves are given in Plates 2-1 to 2-4 inclusive. Strain-time curves for the above gage points have been superimposed in Plates 2-5 and 2-6 in an attempt to show variation in strain pattern along the instigated crack. For gage positions see Plate 2-15.

Curves in Plate 2-5 represent the strain history at the instigated crack during the first two weeks of the pavement life, while curves in Plate 2-6 represent strain history from the time of concrete placing until the prepared bars yielded in tension at the gage points.

A very good correlation between strain in the reinforcing steel, crack width, and average slab temperature is shown in Plate 2-6.

It may be seen from the curves in Plates 2-5 and 2-6 that largest variations in strain in the steel spanning the crack occurred in the south lane, the differences increase with the increase in strain. The strains in the steel spanning crack in north lane are of the same magnitude as in the south lane, but they are nore consistent with the maximum variation of 200 micro inches/inch.

Measurements taken on November 28th, 1958 when the test section was 57 days old, and the average slab temperature was -3°F., show that the crack had opened to 0.067 inches and the reinforcing steel spanning the crack was strained to an average of 1730 micro inches/inch tension. The maximum strain recorded at one gage point was 1900 micro inches/inch.

This was the lowest temperature at which measurements were made on the gages before the reinforcing steel spanning the crack strained past its yield point.

Strain Pattern at Gage Points Away From the Crack

Strain history at gage points on each side of the instigated crack is shown in Plates 2-7 to 2-10 inclusive.

In order to show strain distribution along the reinforcing bar away from the crack, strain versus L/D curves were plotted (Plate 2-11).

During the first five weeks after construction when strain in the steel bars at the crack remained in the low elastic range, strain along the bar decreased at a diminishing rate for a distance of about 30 inches from the crack, and then began to increase gradually. When the reinforcing steel spanning the crack strained past the yield point, strain of 1400 micro inches/inch was measured at the gage point 16 bar diameters from the crack and 1260 micro inches/inch 24 bar diameters from the crack. It may be concluded that loss of bond at the instigated crack extended to a point about 27 bar diameters from the crack.

The very close relationship between strain in the reinforcing steel, crack width, and average slab temperature is shown in Plate 2-6.

Curves in Plates 2-12, 2-13 and 2-14 show that definite relationship existed between strain in reinforcing steel and crack width, temperature and crack width, temperature and strain, when strain in the reinforcing steel remained within elastic range.

Extrapolation of steel strain-crack width curve, temperature-crack width curve and temperature-strain curve indicated that the reinforcing steel at the instigated crack began to yield at a slab temperature of -10°F., and the crack opened to 0.07 inches.

Measurements taken 113 and 133 days after construction indicate that after the reinforcing steel yielded in tension cracks opened to 0.107 and 0.115 inches when the slab temperature was -2 and -4°F. respectively (Plate 2-13).

If higher yield point strain reinforcing steel had been used, the crack would not have opened to such an objectionable width but perhaps additional cracks would have developed.

During the early pavement life, constant temperature cycling prevented the formation of adhesive bond, and only mechanical bond was developed at the extreme limits of the differential movement between the concrete and the deformations in the reinforcing bar. This differential movement was most significant for a distance of about 27 inches on each side of the crack, and decreased at a diminishing rate as the distance from the crack became greater.

This behaviour of the pavement during its early life had a significant effect on future strain history and crack width pattern at the instigated crack.

The shape of the strain-crack width curve suggests that when the reinforcing steel at the crack was in the low to medium elastic range, the width of the crack increased in proportion to the strain in the steel at a rate of about 70 micro inches of crack opening per every micro inch of strain in the reinforcing steel. In the high elastic range, the width of the crack increased in proportion to strain but at a greatly reduced rate (Plate 2-12).

With the approach of a cooling cycle when temperature dropped below 50°F. the width of the instigated crack increased in proportion to drop in temperature (Plate 2-13).

Conclusions

The data seem to indicate that the reinforcing steel at the instigated crack began to yield when slab temperature dropped to about -10°F. Measurements taken on November 27th, 1958 show that yield point strain of the steel had been reached at least at some of the gage locations when the slab temperature was -3°F. and the crack opened to 0.0685 inches.

After the reinforcing bars spanning the crack yielded in tension, the width of the instigated crack exceeded 0.12 inches.

Temperature records at the Calgary airport indicate that the lowest temperature recorded for the winter season was -25°F. Assuming no yielding of the reinforcing steel, it is probable that at this extreme low in temperature, the crack would have opened to 0.088 inches.

The loss of bond between the reinforcing bars and the concrete extended to a point about 27 bar diameters from the crack. This comparatively large loss of bond had an adverse effect on the width of the crack opening.

(c) Comparison of Results at Location I and Location II

Concrete was placed at the gaged panel, Location I, on September 30, 1958 and at gaged panel, Location II, on October 1st of the same year. After the first set of readings was taken at Location II, all the subsequent measurements at the two locations were taken about one-half hour apart.

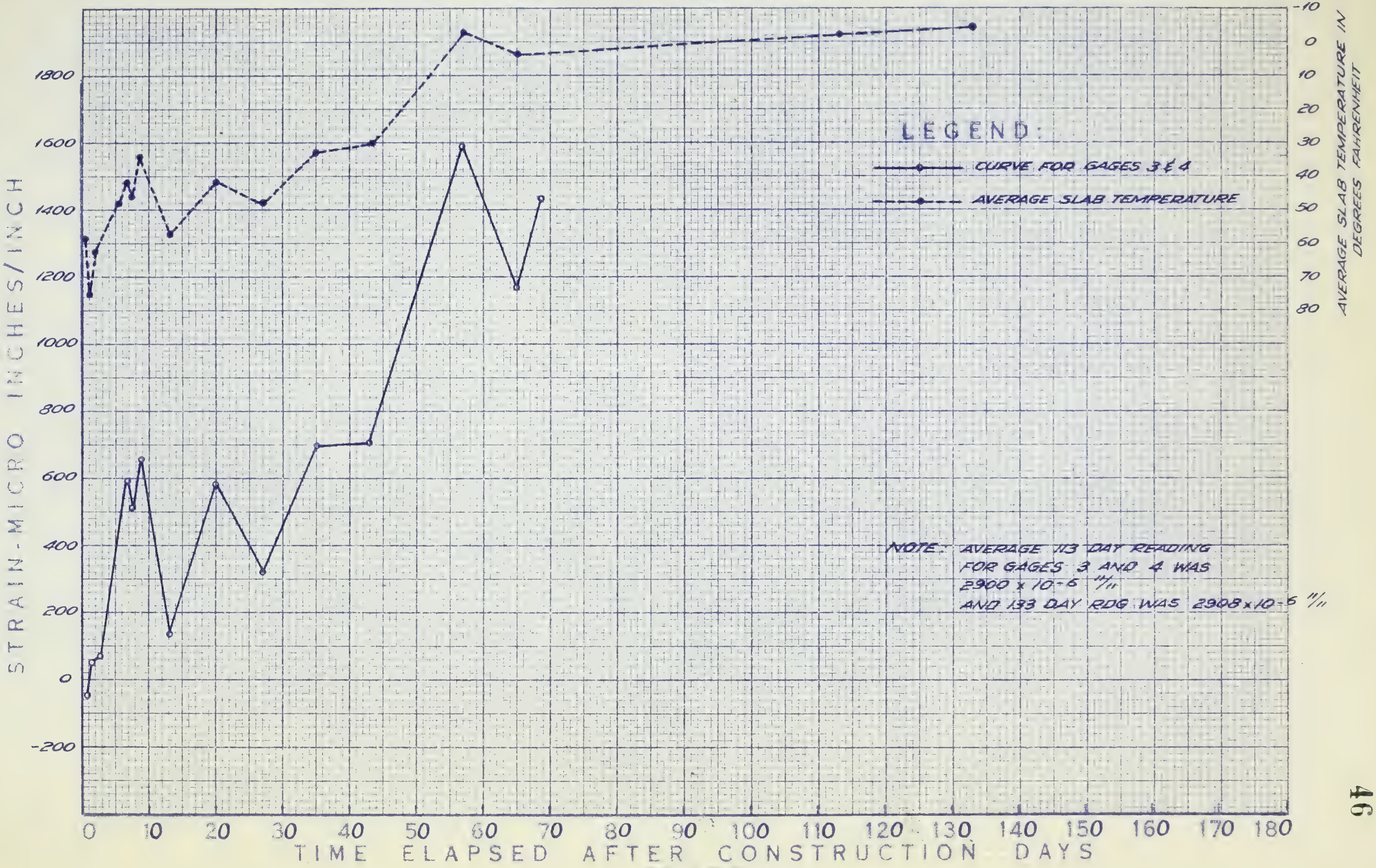
During the first six weeks after construction close relationship existed between strain in the reinforcing steel and the crack width at the two locations. Reinforcing steel at Location II was subjected to somewhat larger strains than at Location I. Strains of 820 and 910 micro inches/inch were measured at Locations I and II when the pavement was 44 days old. Average crack width at both locations was 0.03 inches when the above strain measurements were taken.

The effect of sub-freezing temperature was more pronounced at Location II. Measurements taken 58 days after construction, when slab temperature was about 0^{o}F., indicated that the reinforcing steel at the crack was strained to 1650 micro inches/inch at Location I and 1900 micro inches/inch at Location II, and the instigated crack opened to 0.049 inches and 0.064 inches at the two respective locations.

Examination of strain transfer distribution curves (Plates 1-8 and 2-11) reveals that loss of bond at Location II extended much further from the crack than at Location I. Greater loss of bond combined with larger strains in the reinforcing steel account for the wider crack opening at Location II.

STRAIN-TIME CURVES

SECTION TYPE B7-2 LOCATION II STATION 357+00

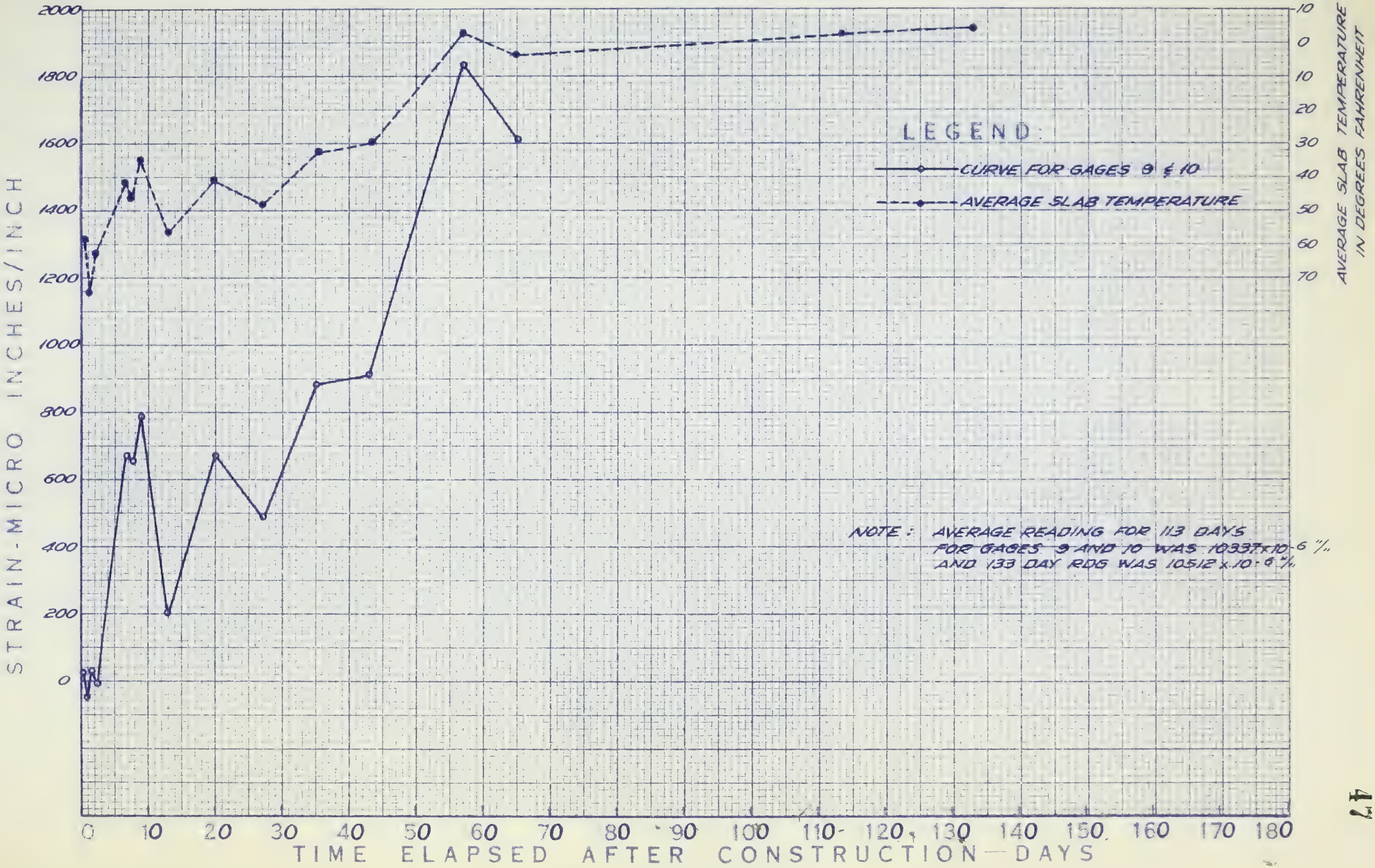


NOTE: AVERAGE 113 DAY READING FOR GAGES 3 AND 4 WAS 2900 x 10-6 "/" AND 133 DAY RDG WAS 2908 x 10-6 "/"

PLATE 2-1

STRAIN—TIME CURVES

SECTION TYPE B7-2 LOCATION II STATION 357+00



NOTE: AVERAGE READING FOR 113 DAYS FOR GAGES 9 AND 10 WAS 10337 x 10⁻⁶ %, AND 133 DAY RDG WAS 10512 x 10⁻⁶ %.

PLATE 2-2

STRAIN - TIME CURVES

SECTION TYPE B7-2 LOCATION II STATION 357+00

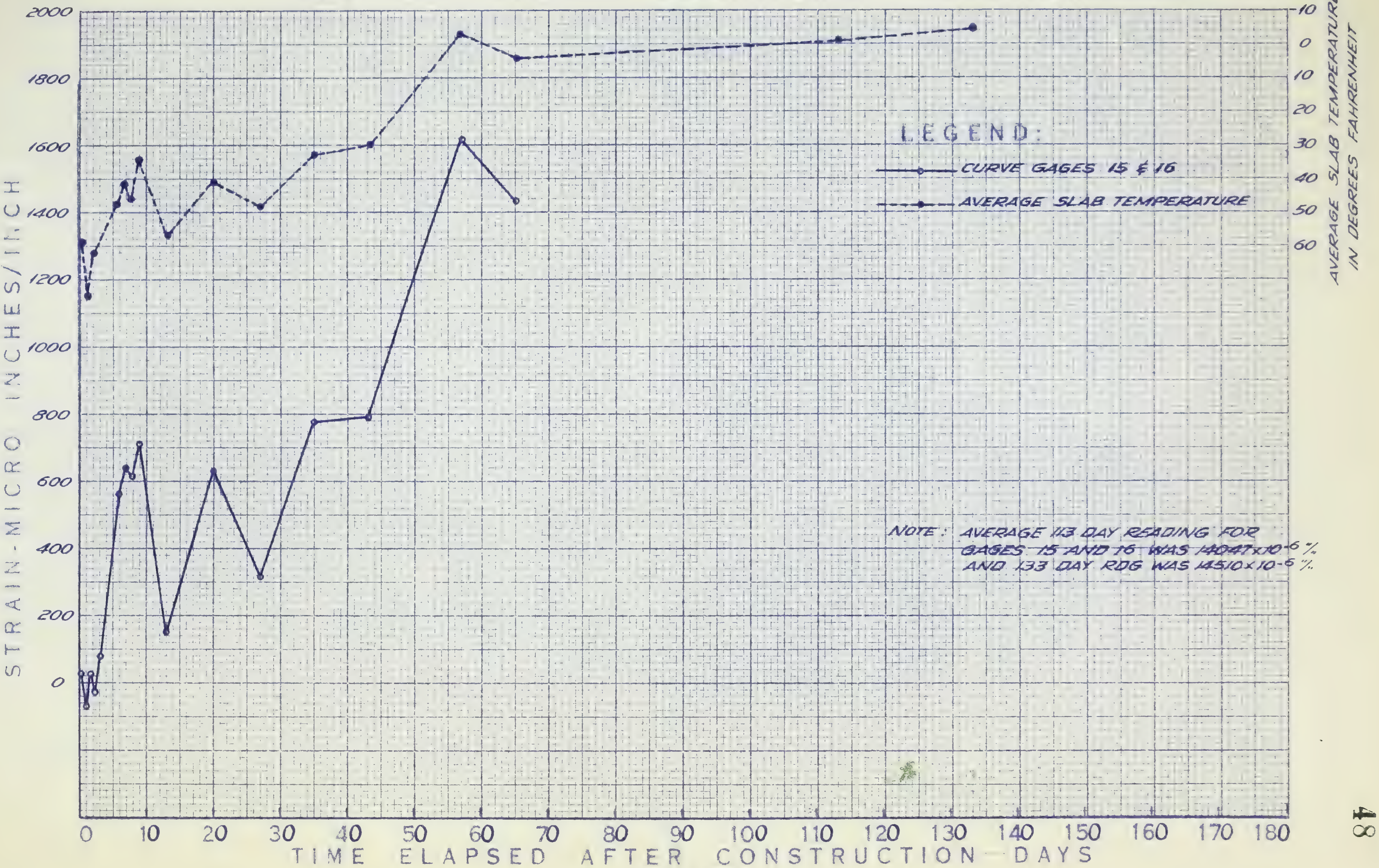


PLATE 2-3

STRAIN TIME CURVES

SECTION TYPE *B7-2* LOCATION *II* STATION *357+00*

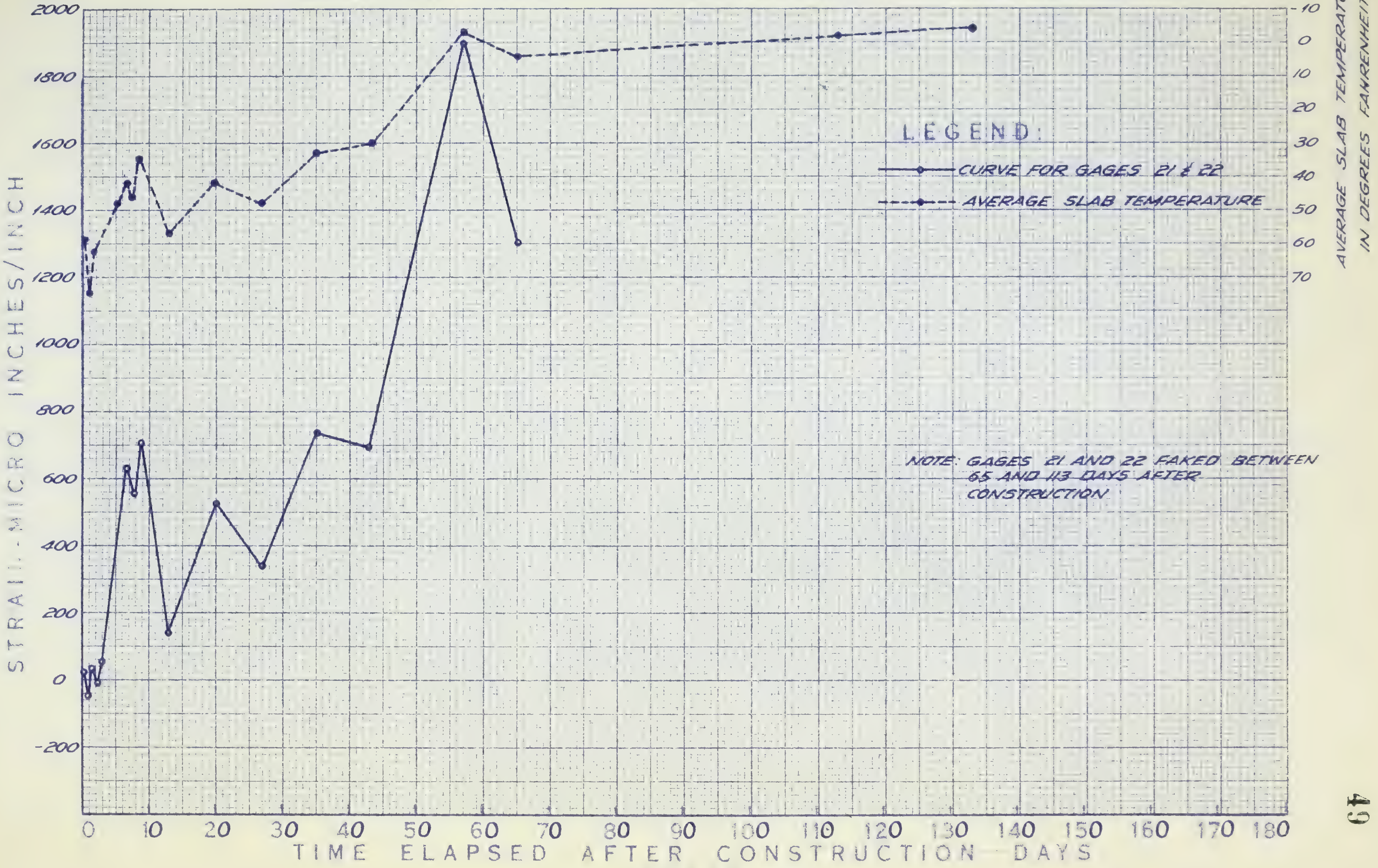


PLATE *2-4*

STRAIN TIME CURVES

SECTION TYPE B7-2 LOCATION II STATION 357+00

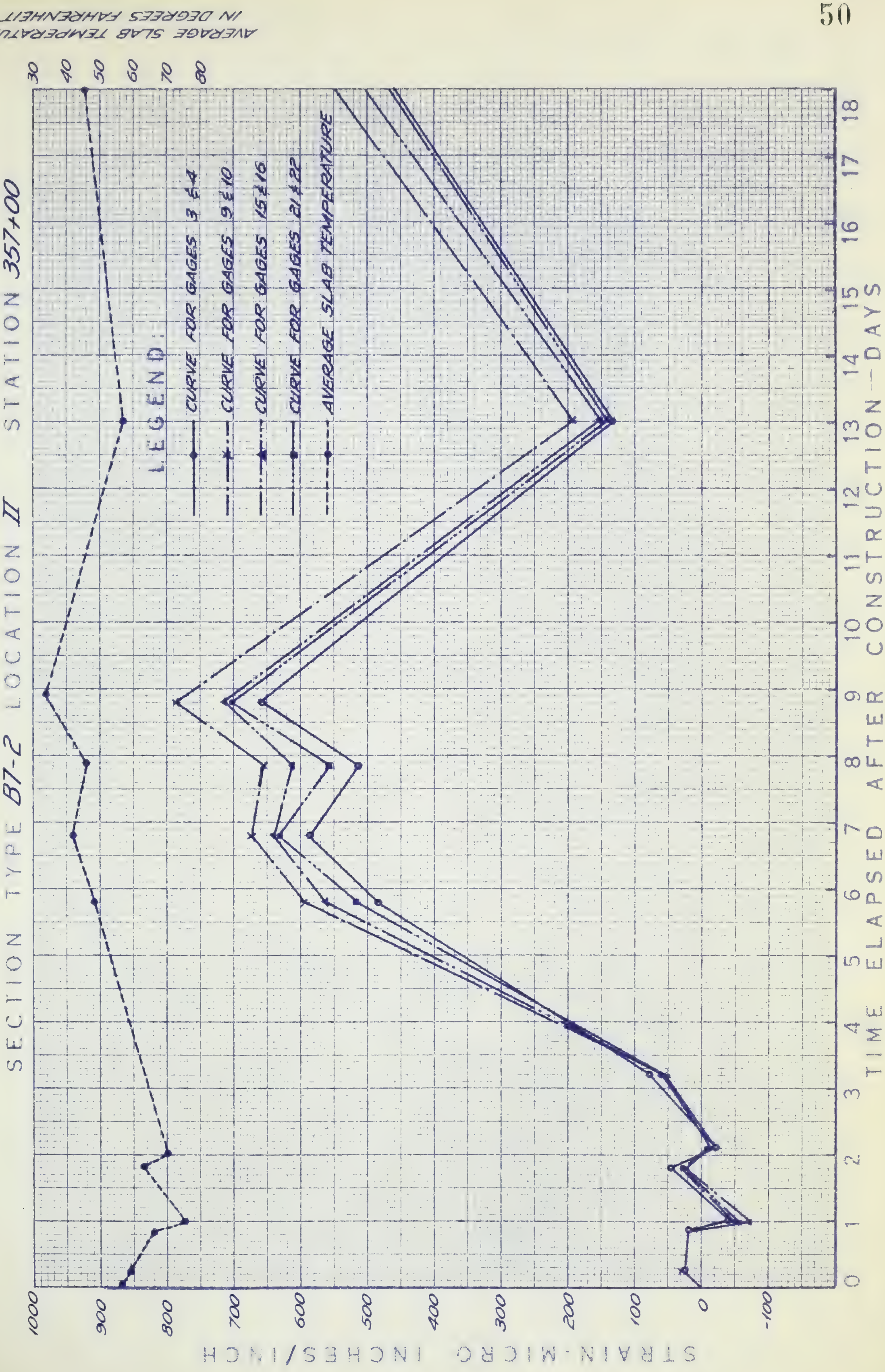
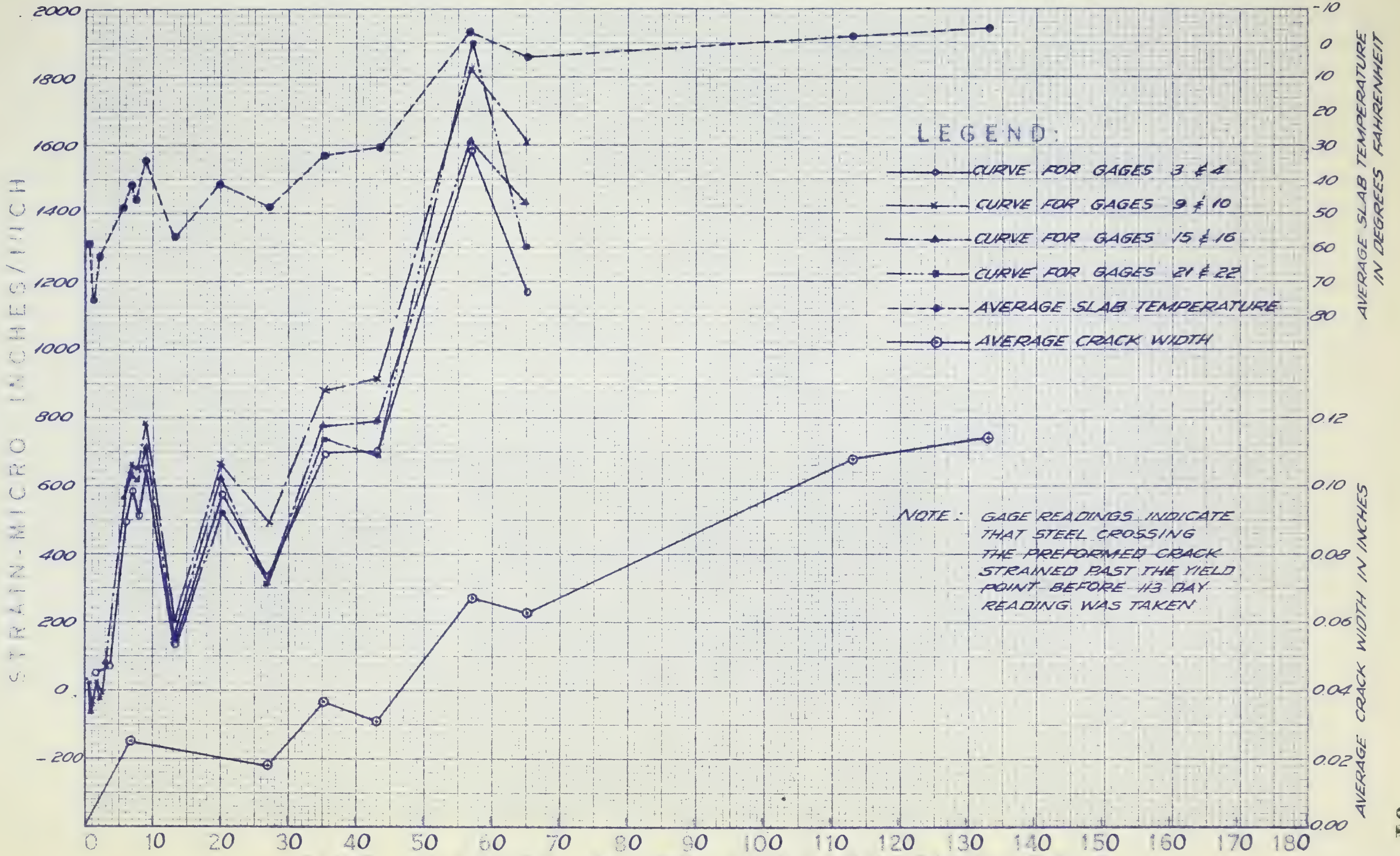


PLATE 2-5

STRAIN-TIME CURVES

SECTION TYPE B7-2 LOCATION II STATION 357+00



NOTE: GAGE READINGS INDICATE THAT STEEL CROSSING THE PREFORMED CRACK STRAINED PAST THE YIELD POINT BEFORE 113 DAY READING WAS TAKEN

PLATE 2-6

STRAIN TIME CURVES

SECTION TYPE B7-2 LOCATION II STATION 357+00

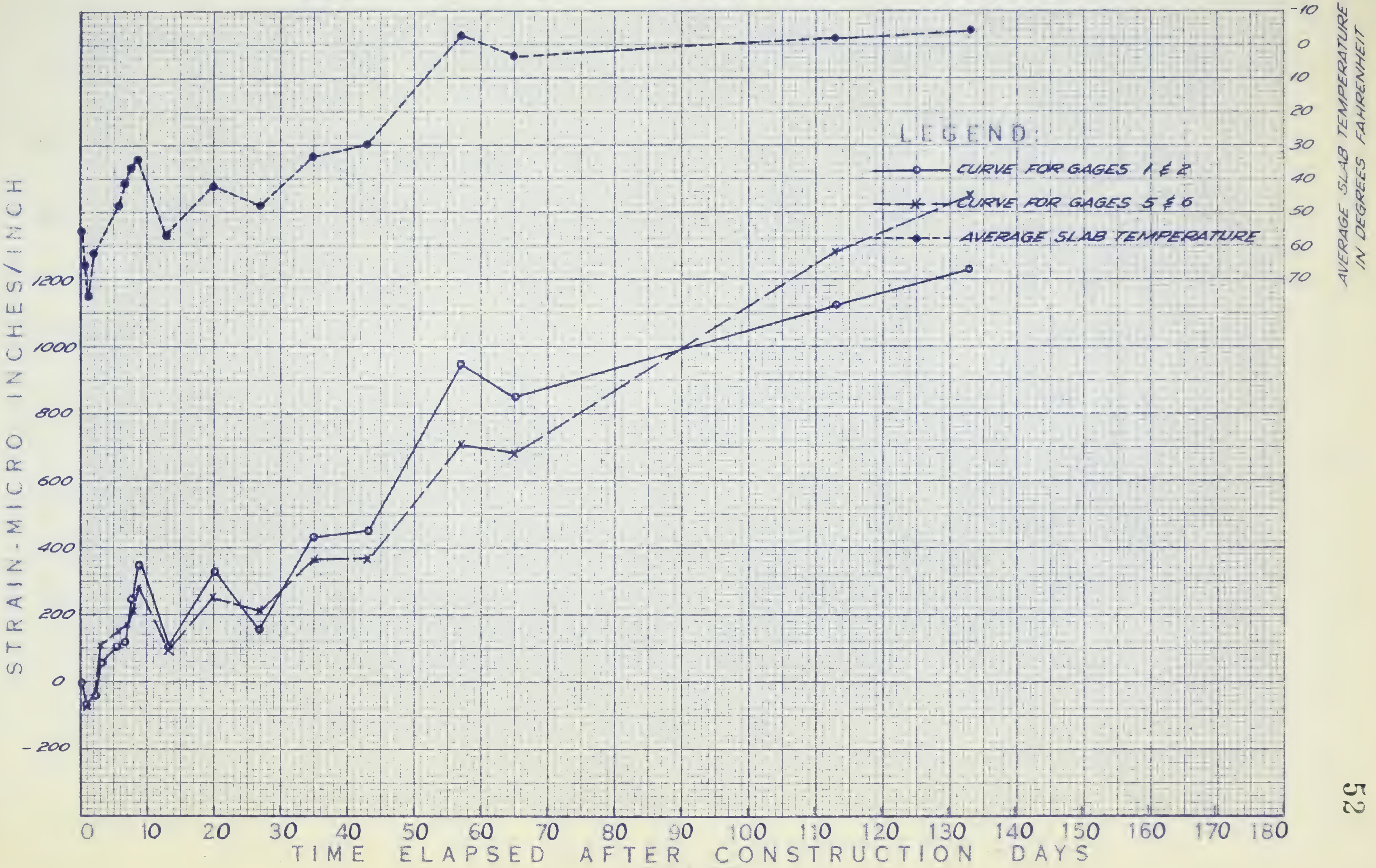


PLATE 2-7

STRAIN TIME CURVES

SECTION TYPE *B7-2* LOCATION *II* STATION *357+00*

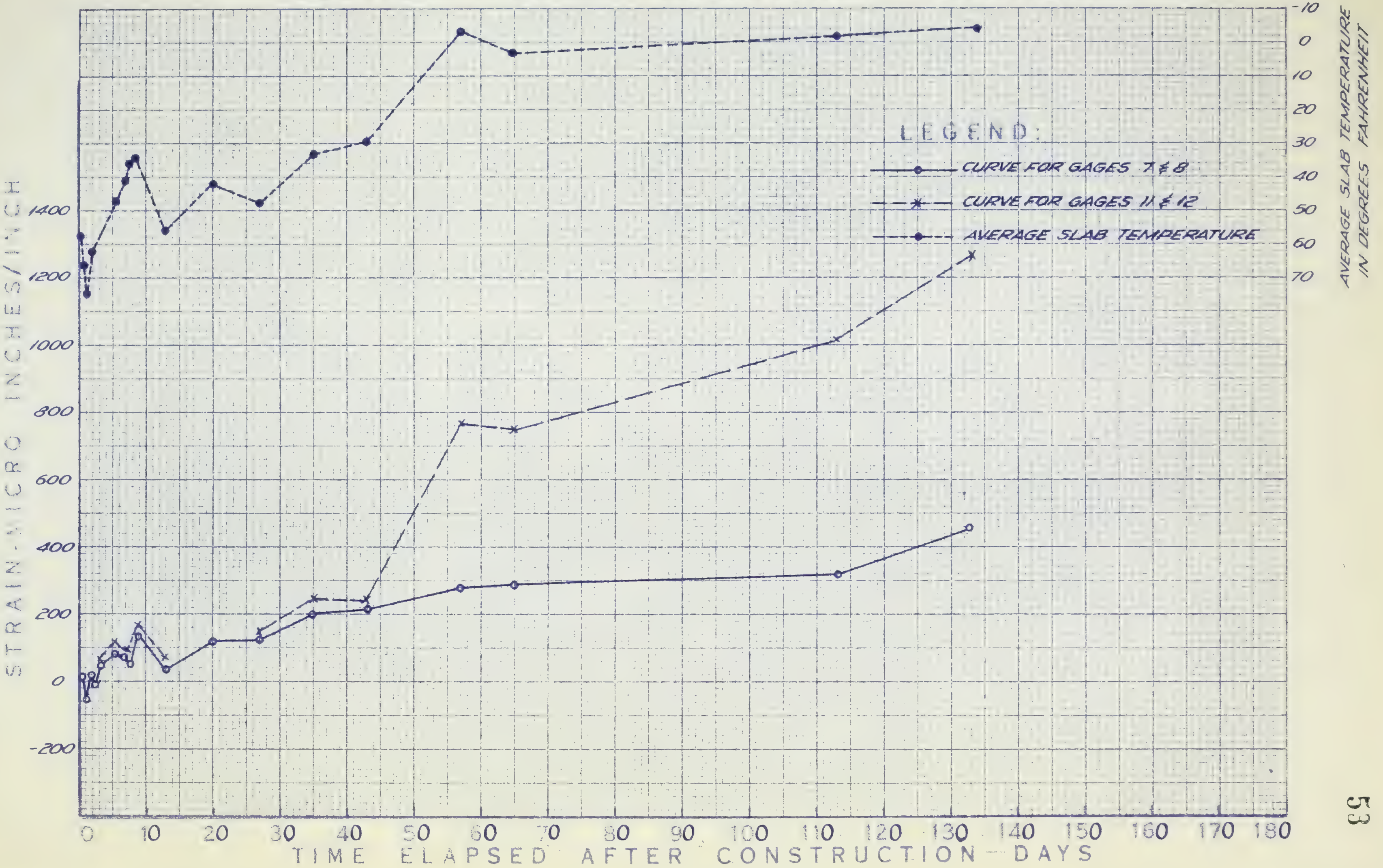


PLATE *2-8*

STRAIN TIME CURVES

SECTION TYPE B7-2 LOCATION II STATION 357+00

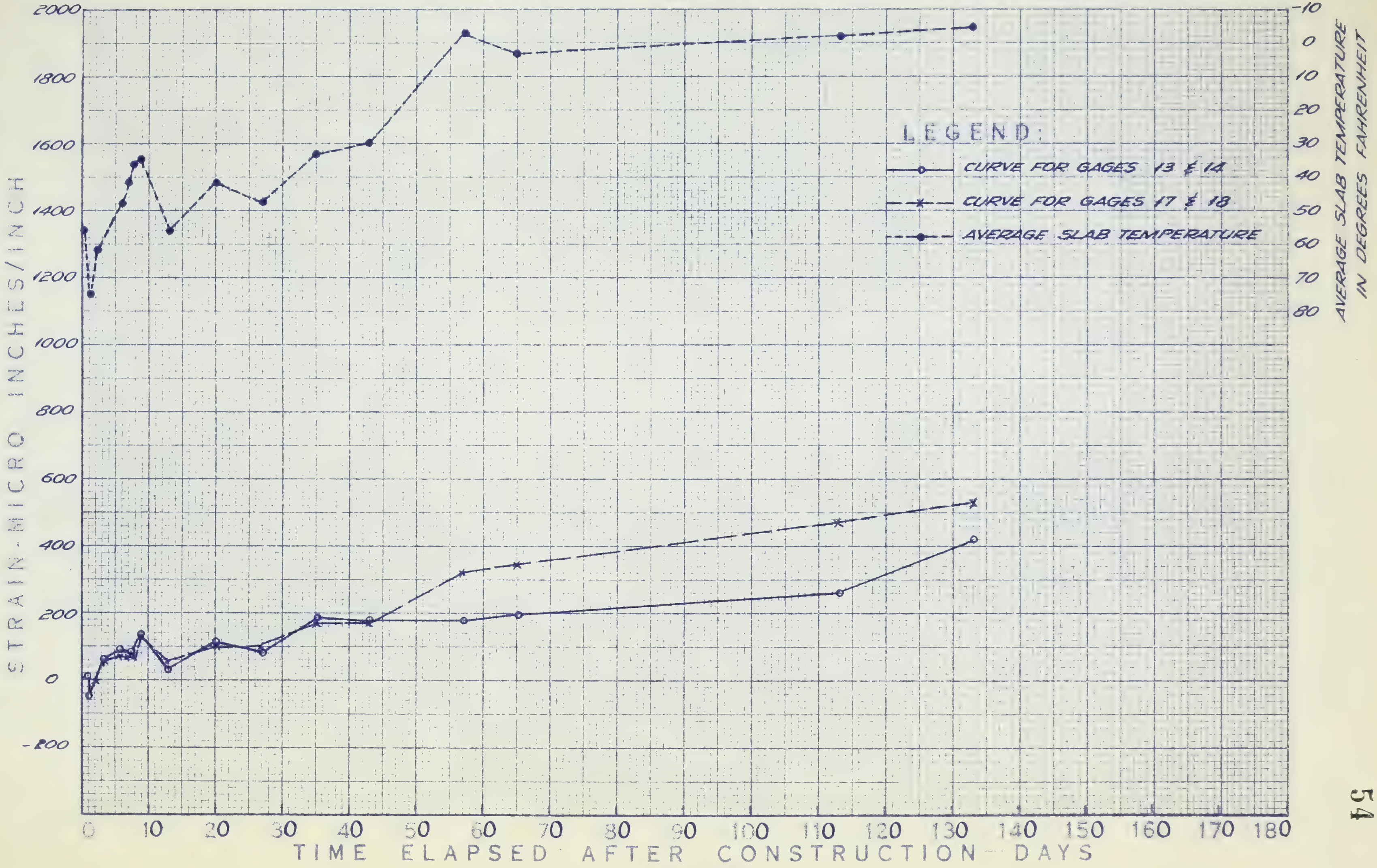


PLATE 2-9

STRAIN TIME CURVES

SECTION TYPE *B7-2* LOCATION *II* STATION *357+00*

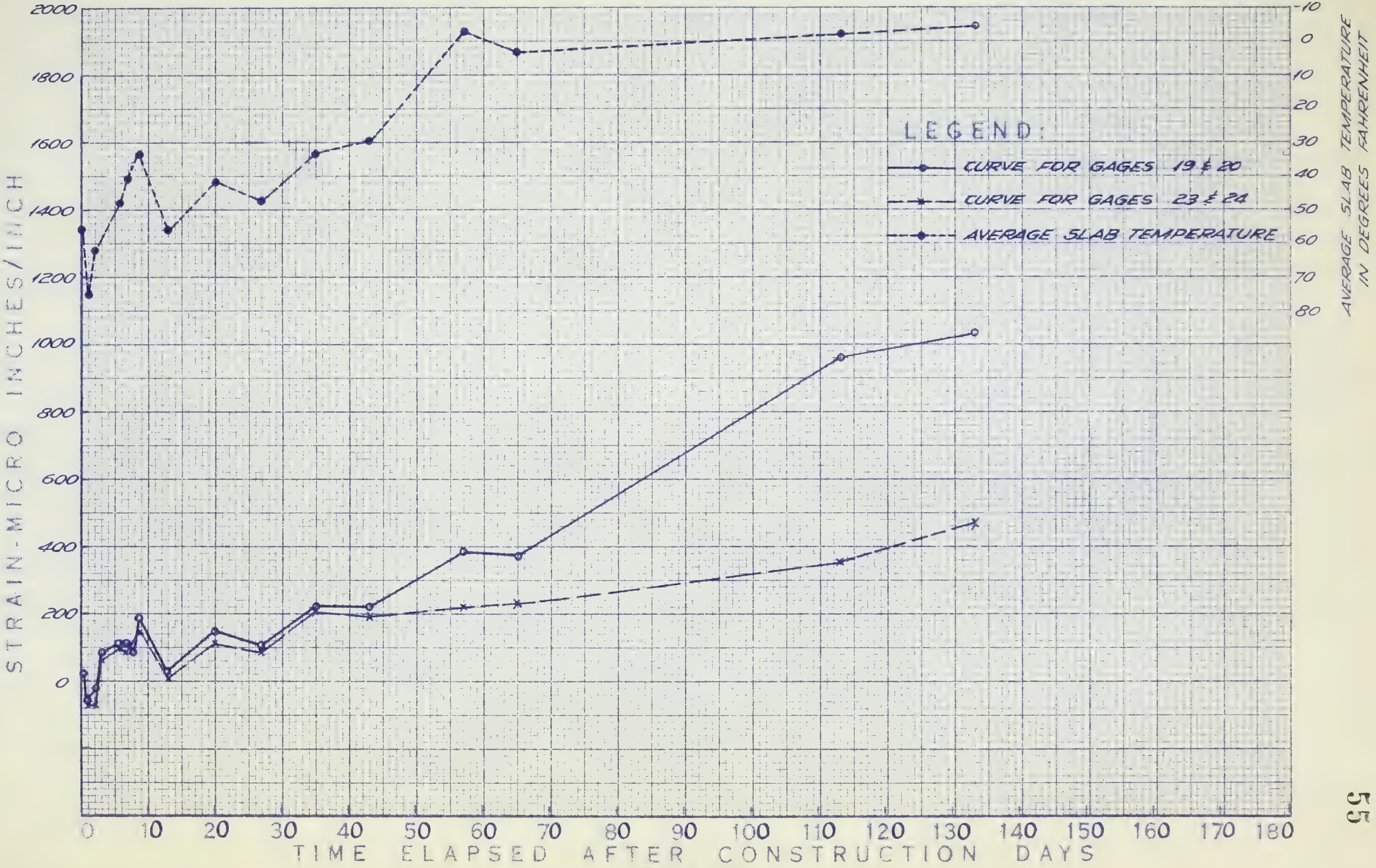


PLATE *2-10*

STRAIN TRANSFER DISTRIBUTION CURVE

SECTION TYPE B7-2 LOCATION II STATION 357+00

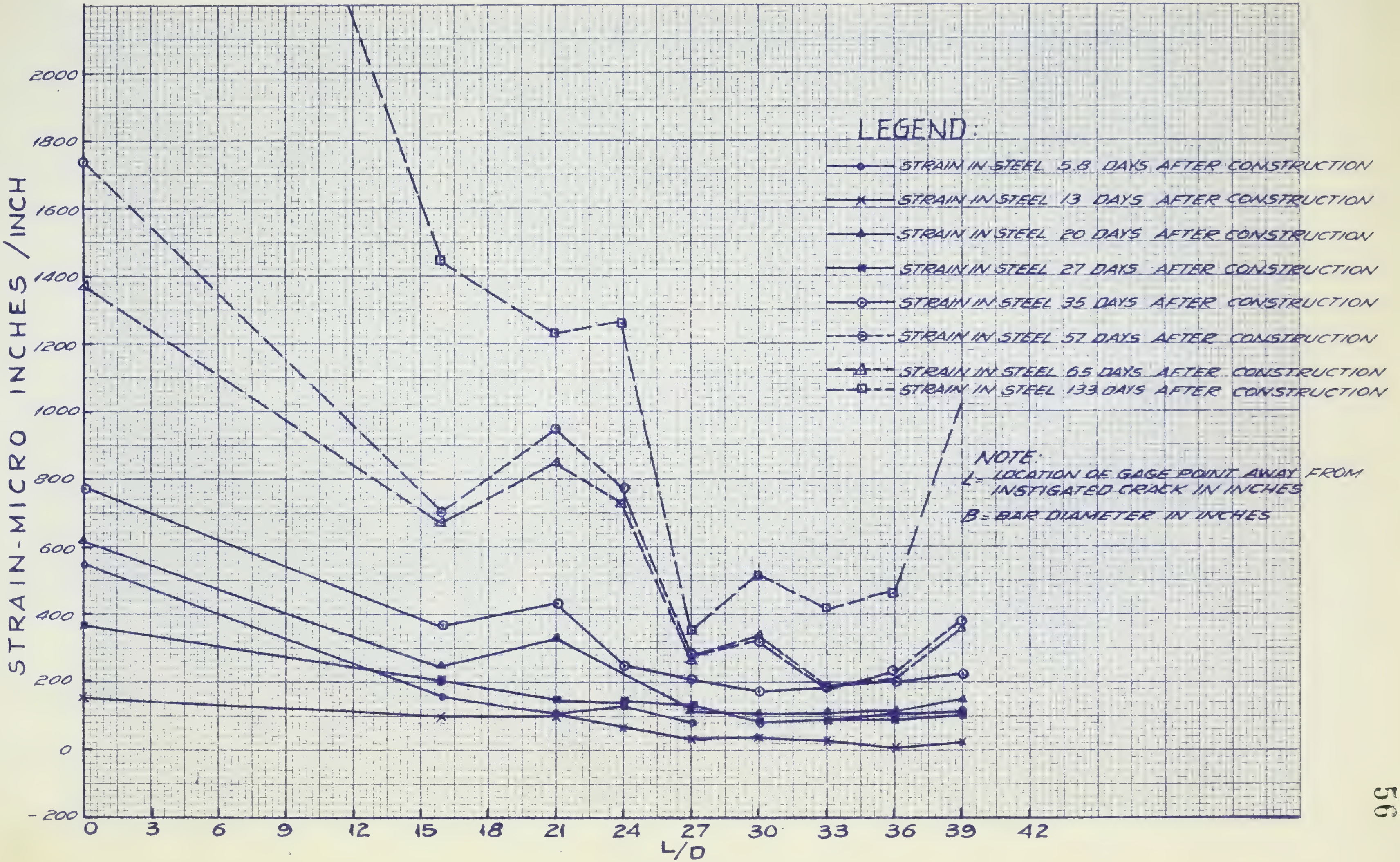


PLATE 2-11

STEEL STRAIN - CRACK WIDTH CURVE

SECTION TYPE B7-2 LOCATION II STATION 357+00

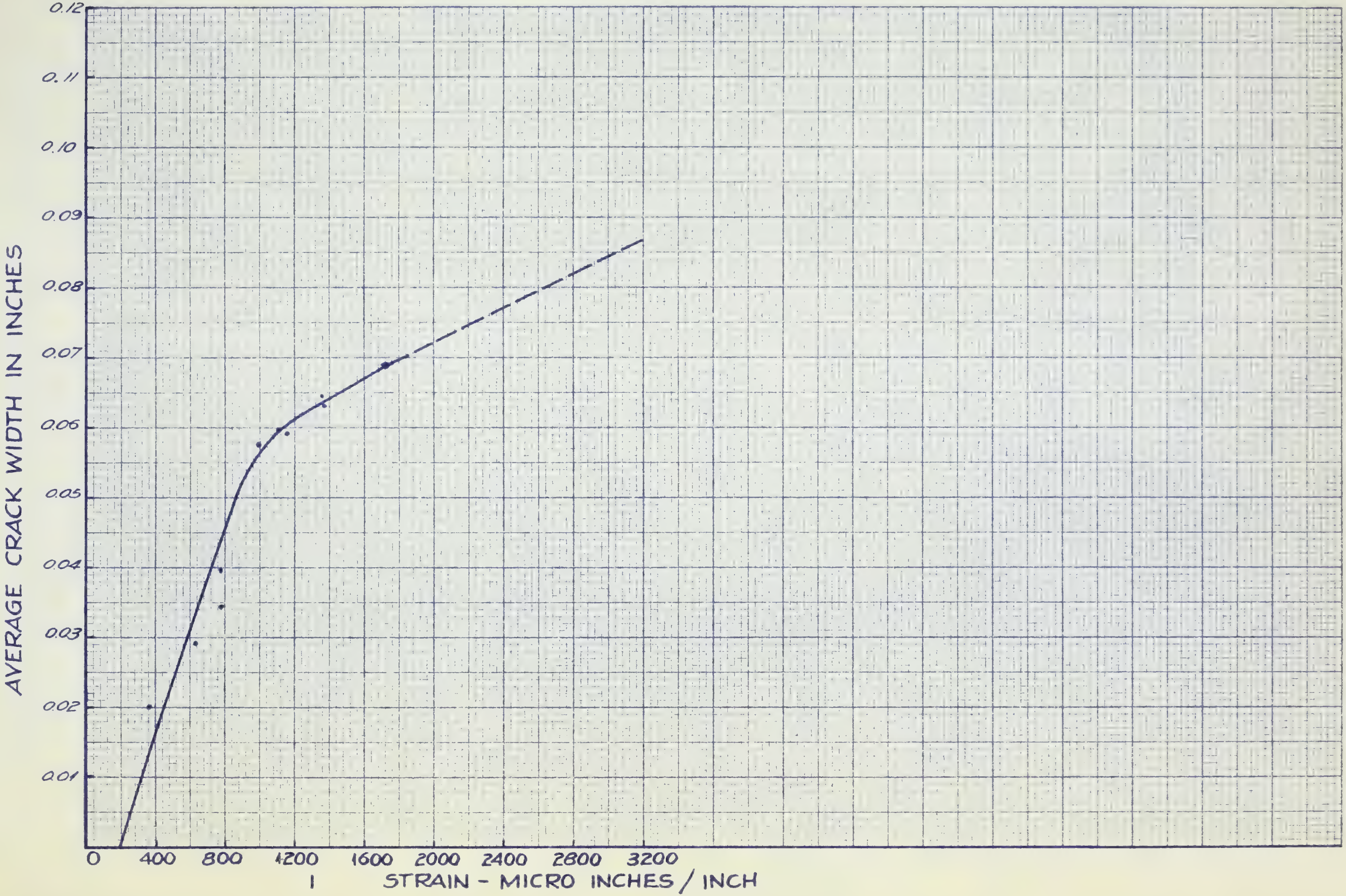
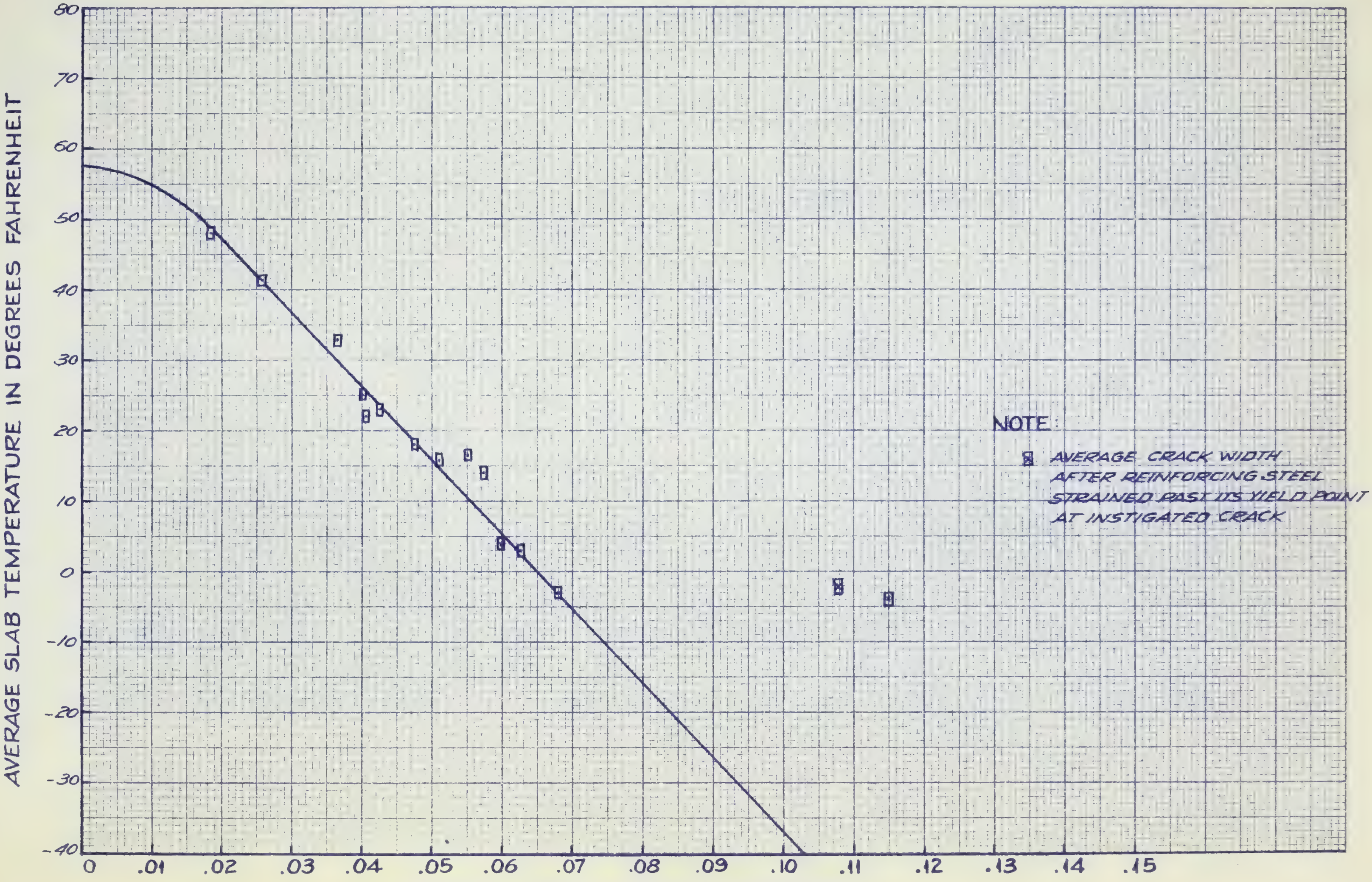


PLATE 2-12

CRACK WIDTH - SLAB TEMPERATURE CURVE

SECTION TYPE-B7-2 LOCATION II - STATION 357+00

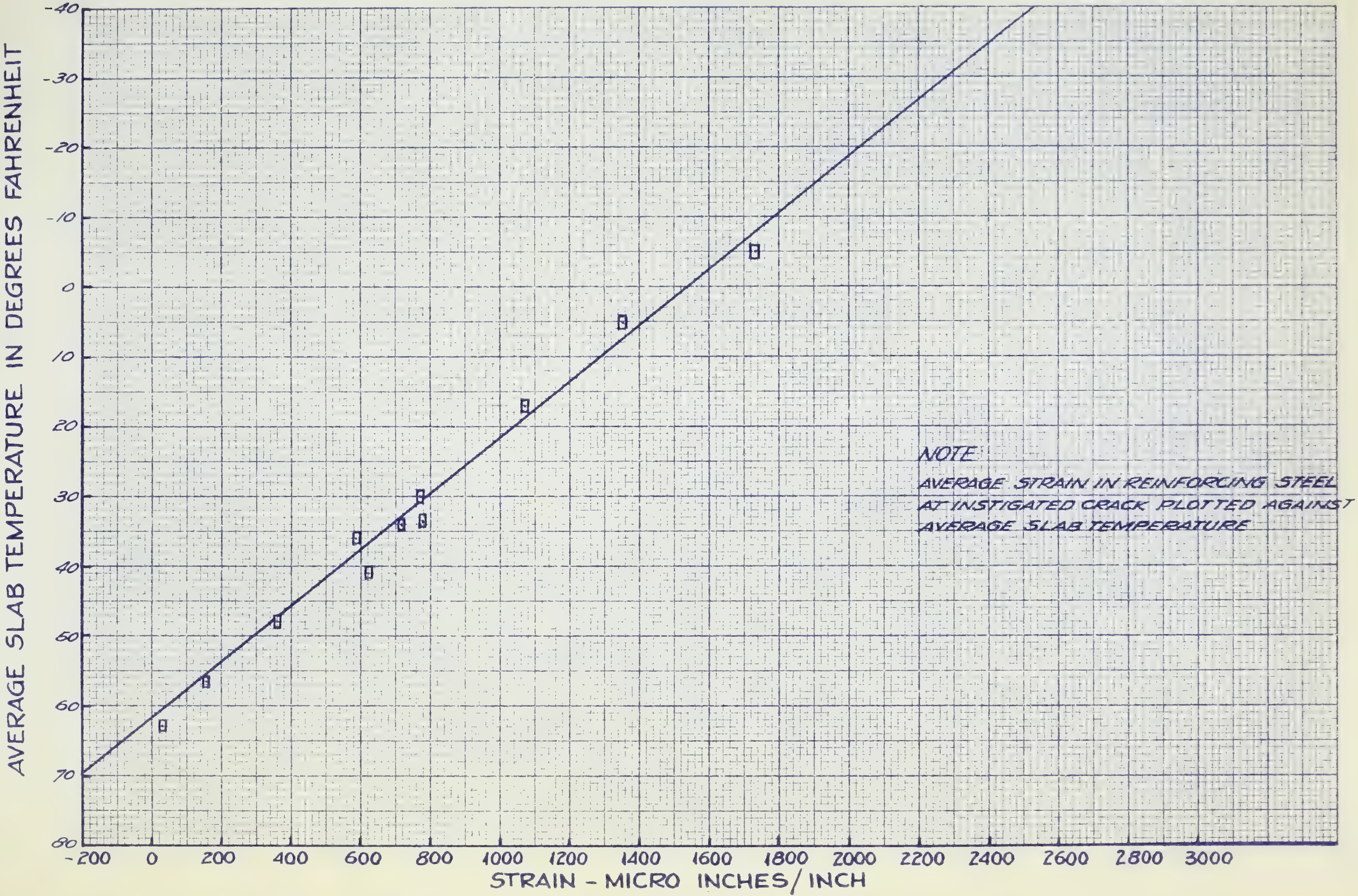


NOTE:
⊠ AVERAGE CRACK WIDTH AFTER REINFORCING STEEL STRAINED PAST ITS YIELD POINT AT INSTIGATED CRACK

PLATE 2-13

STRAIN-TEMPERATURE CURVE

SECTION TYPE B7-2 LOCATION II STATION 357+00



NOTE
AVERAGE STRAIN IN REINFORCING STEEL
AT INSTIGATED CRACK PLOTTED AGAINST
AVERAGE SLAB TEMPERATURE

PLATE 2-14

SECTION TYPE B7-2

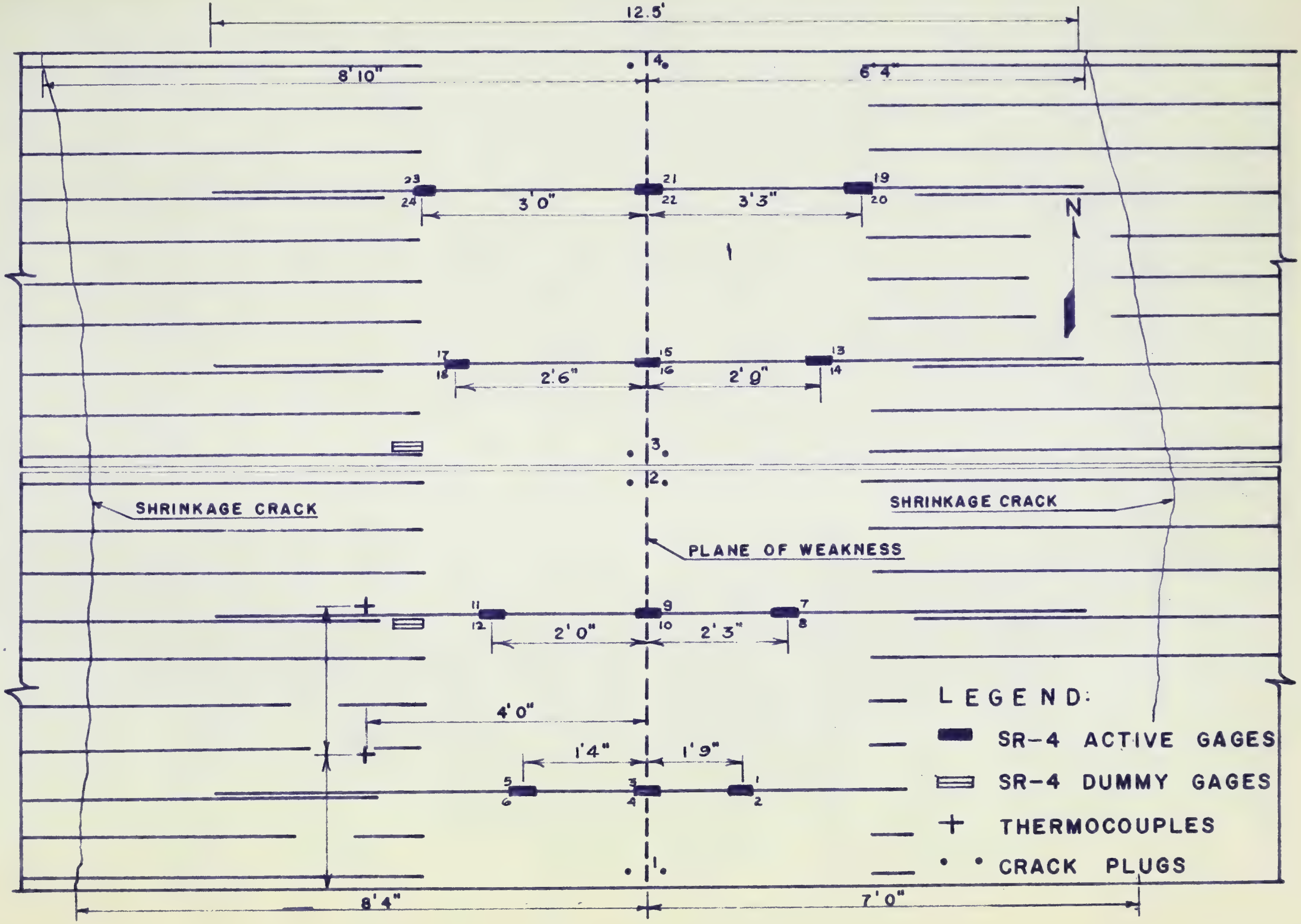


PLATE 2-15

2. Section Type B7-1

Concrete pavement Type B7-1, 2645 feet in length, consists of a 7 inch slab reinforced with No. 8 intermediate grade deformed steel bars comprising a 0.706% cross-section area of the pavement (Plate 4).

The test section was located at station 334+00 approximately 4,072 feet from the expansion dam, constructed at the west end of the pavement (Plate 6).

Concrete at the test section referred to from here on as Location III was poured on October 6, 1958 about 4.00 p.m. The first strain gage readings were taken immediately after the finishing operation. These readings served as the basis for all subsequent strain measurements. Out of 24 strain gages, gages 1, 2, and 24 could not be connected to the terminal box. (For gage positions see Plate 3-14.)

Curves in Plates 3-1 to 3-6 inclusive represent the strain history at the induced crack. Curves in Plates 3-1 to 3-4 represent the strain history for the individual gage points. Curves for the individual gage points have been superimposed in Plates 3-5 and 3-6 in an attempt to determine the strain pattern along the transverse crack. Curves in Plates 3-7 to 3-9 inclusive represent the strain history at gage points away from the crack.

During the first two weeks after construction, the reinforcing steel in the south lane was subjected to considerably larger strains than in the north lane (Plate 3-7).

A good relationship between strain in the reinforcing steel, crack width, and average slab temperature is shown in Plate 3-6.

Some trends became apparent when concrete was several days old. Curves in Plates 3-10, 3-11 and 3-12 suggest that definite relationships existed between the strain in the steel and crack width, temperature and crack width, temperature and strain, as long as the reinforcing steel spanning the crack remained in the elastic range.

By extrapolation of temperature-strain curve and strain-crack width curve, combined with a knowledge of reinforcing steel characteristics (Plate 9), it may be shown that the reinforcing steel began to yield at the instigated crack at a slab temperature of about -15°F., and the crack probably opened up to 0.038 inches. Extrapolation of temperature-crack width curve reveals that at -15°F. the crack would open to 0.036 inches. It may also be shown that if the reinforcing steel, having higher yield point strain had been used, no yielding would have taken place at the cracks. As a result, additional cracks would have probably formed at very low temperatures and the existing cracks would not have opened to objectionable widths.

During December of 1958, measurements were made at a slab temperature of 6°F. when the pavement was 60 days old. These measurements indicated that the strain in the reinforcing steel at the crack reached 1,350 micro inches/inch and that the crack opened to 0.03 inches.

This was the lowest temperature at which measurements

were made on the gages before the reinforcing bars yielded in tension. It may be pointed out that a temperature of -13°F. was recorded at the Calgary airport on November 26, 1958 before the 60-day readings were taken. It is possible that the strain in the reinforcing steel approached the yield point at that temperature.

Measurements that were made on January 22 of 1959 when the pavement was 108 days old, revealed that the crack opened to 0.036 inches, the reinforcing bars at the crack were strained to about 7,000 micro inches/inch in tension, or well beyond the yield point, and the slab temperature was -1.5°F.

Temperature records at the Calgary airport indicate that during the second week of December, 1958 and the first week of January, 1959 a low of -12°F. and -25°F. respectively was recorded.

It is believed that during the time when the pavement was subjected to these low temperatures, reinforcing bars spanning the crack strained past the yield point and the cracks opened much wider.

Strain measurements at the gage points away from the plane of weakness indicated that the loss of bond between the concrete and the steel extended to a point about 24 bar diameters, or in this case 24 inches from the crack (Plate 3-13).

During the first few days of pavement life, shrinkage crack formed in the vicinity of the plane of weakness (Plate 3-14). Strain data indicate that the shrinkage crack developed before the pavement cracked at the plane of weakness. It is quite possible that this shrinkage crack formed before the plane of weakness was induced. It must be pointed out that

on numerous occasions the plane of weakness was induced after the concrete was 3 to 5 days old.

The shrinkage crack in the vicinity of the plane of weakness prevented the opening of the instigated crack to objectionable width.

Since the formation of the potential bond between the concrete and the steel was prevented by the application of plastic tape over all the bars for a distance of about 6 inches along the plane of weakness, it is believed that the crack at the plane weakness opened wider than the shrinkage crack for a given drop in temperature.

It may be observed in Plate 3-5 that one of the prepared bars was not subjected to post yield straining. The formation of the two closely spaced cracks in the test section brought about a loss of bond between the gage points 15-16 and 17-18, and some distance beyond; as a result strain in that bar distributed over a relatively long length preventing eventual yielding at low temperatures.

The shape of the strain-crack width curve shown in Plate 3-10 seems to indicate that the width of the crack at the plane of weakness increased at an increasing rate until a certain strain in the reinforcing steel was reached, after which the width of the crack increased in proportion to strain increase. Similarly, temperature-crack width curve shown in Plate 3-11 indicates that the width of the crack increased at a decreasing rate during the early life of pavement when temperatures were above freezing. When the slab was subjected to sub-freezing

temperatures, the crack width increased in proportion with the decrease in temperature.

During the first few days after construction, there seemed to be very little relationship between the magnitude of the strain in the reinforcing bars at the plane of weakness and the slab temperature, even though the reinforcing steel was strain sensitive to the changing temperature. This action continued until the seasonal cooling cycle started, the lower temperatures caused an increase in the steel strain at the crack, and then a reasonable relationship became apparent (Plate 3-12).

Conclusions

(a) Pavement Behaviour when Reinforcing Steel at the Crack Remained in the Elastic Range

Constant temperature cycling during the first few days of pavement life prevented the formation of adhesive bond and only mechanical bond was developed at the extreme limits of the differential movement between the concrete and the deformations on the reinforcing bar.

With the advance of low temperatures and continuing shrinkage, the crack opened beyond the range of free movement and all of the strain was transferred into the reinforcing bar.

Curves in Plates 3-11 and 3-12 indicate that the crack width and the strain in the reinforcing steel at the instigated crack increased in proportion to the decrease in temperature. The upper and lower boundary shown in Plate 3-12 give an indication of the amplitude of the relative movement during the course of the temperature fluctuation.

Curves in Plate 3-13 indicate that the loss of bond extended to a point about 24 bar diameters from the crack.

Strain-crack width curve and temperature crack width curve are quite well defined by points which represent measurements that were made at least 21 days after construction when behaviour of the pavement was well established.

Tension yielding took place in three out of four prepared bars at the instigated crack before 108 day strain measurements were made. It is believed that the steel spanning the crack yielded in tension between the second week of December of 1958 and the first week of January, 1959, during which period

lowest temperatures of the winter season were recorded. The lowest temperature recorded at the Calgary airport was -25°F. during the first week of January, 1959.

The manner in which the reinforcing bars yielded made it very difficult, if not impossible, to determine the average strain once the yield point had been reached. Due to reduction in cross-section area of the bar at the gage location, yielding was localized at the gage points.

Strain history in the reinforcing bars and the crack width pattern at the instigated crack do not truly represent the conditions at the cracks spaced 7 to 10 feet apart due to the fact that an additional crack formed in the vicinity of the plane of weakness.

The marked influence exerted by the shrinkage crack on the strain history and the crack width pattern at the instigated crack leads to the belief that in the absence of this crack, the instigated crack would have opened much wider and the reinforcing steel would have been subjected to higher strains, thus giving better representation of the conditions that existed at the cracks spaced from 7 to 10 feet apart.

(b) Pavement Behaviour After the Reinforcing Steel Yielded in Tension

When the pavement was subjected to extreme sub-zero temperatures reinforcing steel at the cracks yielded in tension and cracks opened to objectionable widths.

A simple calculation will reveal that the potential tensile force that may be developed in the concrete slab is

much higher than that which may be developed in reinforcing steel at the yield point strain. For this reason instead of additional cracks being formed, the steel yielded at existing cracks.

STRAIN TIME CURVES

SECTION TYPE B7-1 LOCATION III STATION 334+00

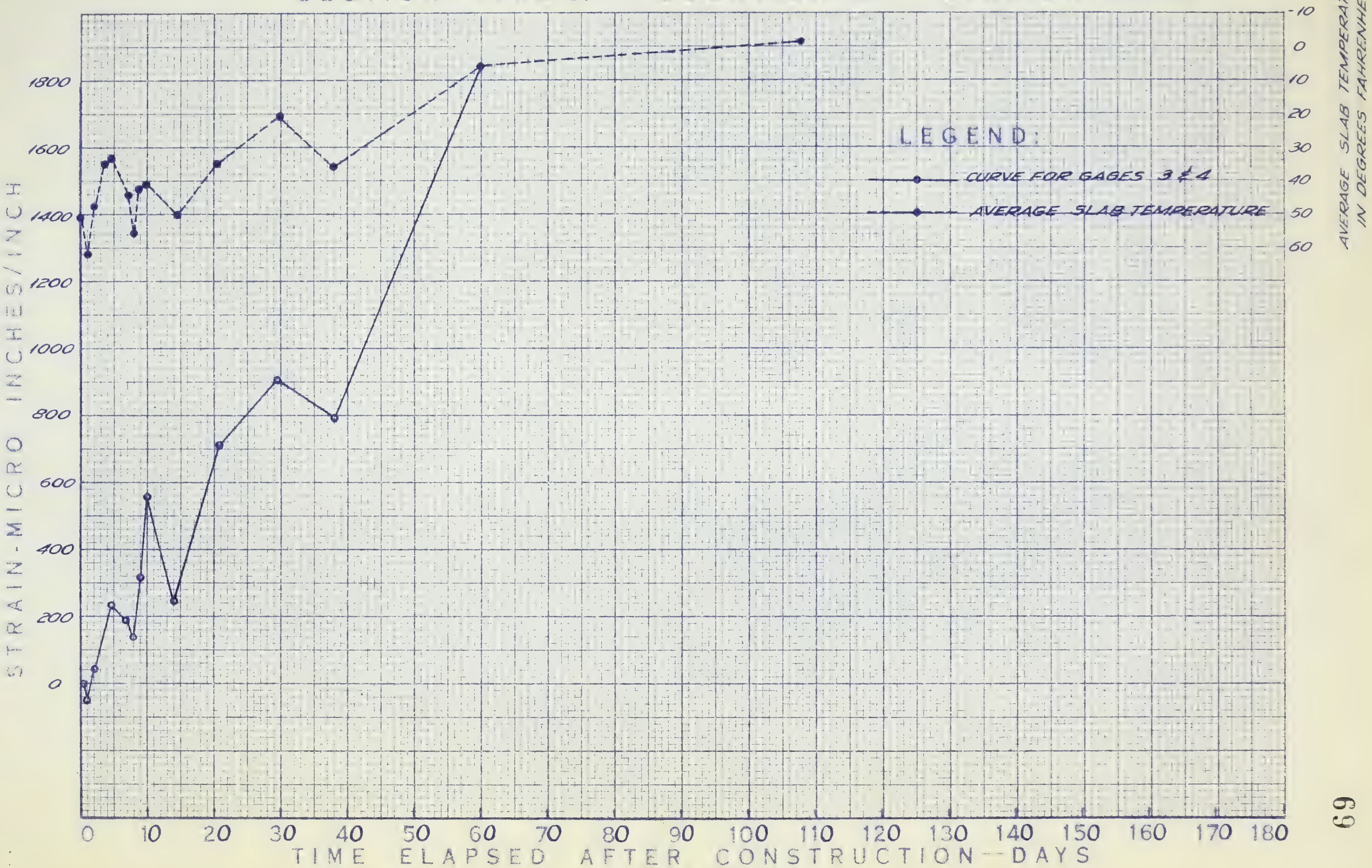


PLATE 3-1

STRAIN TIME CURVES

SECTION TYPE *B7-1* LOCATION *III* STATION *334+00*

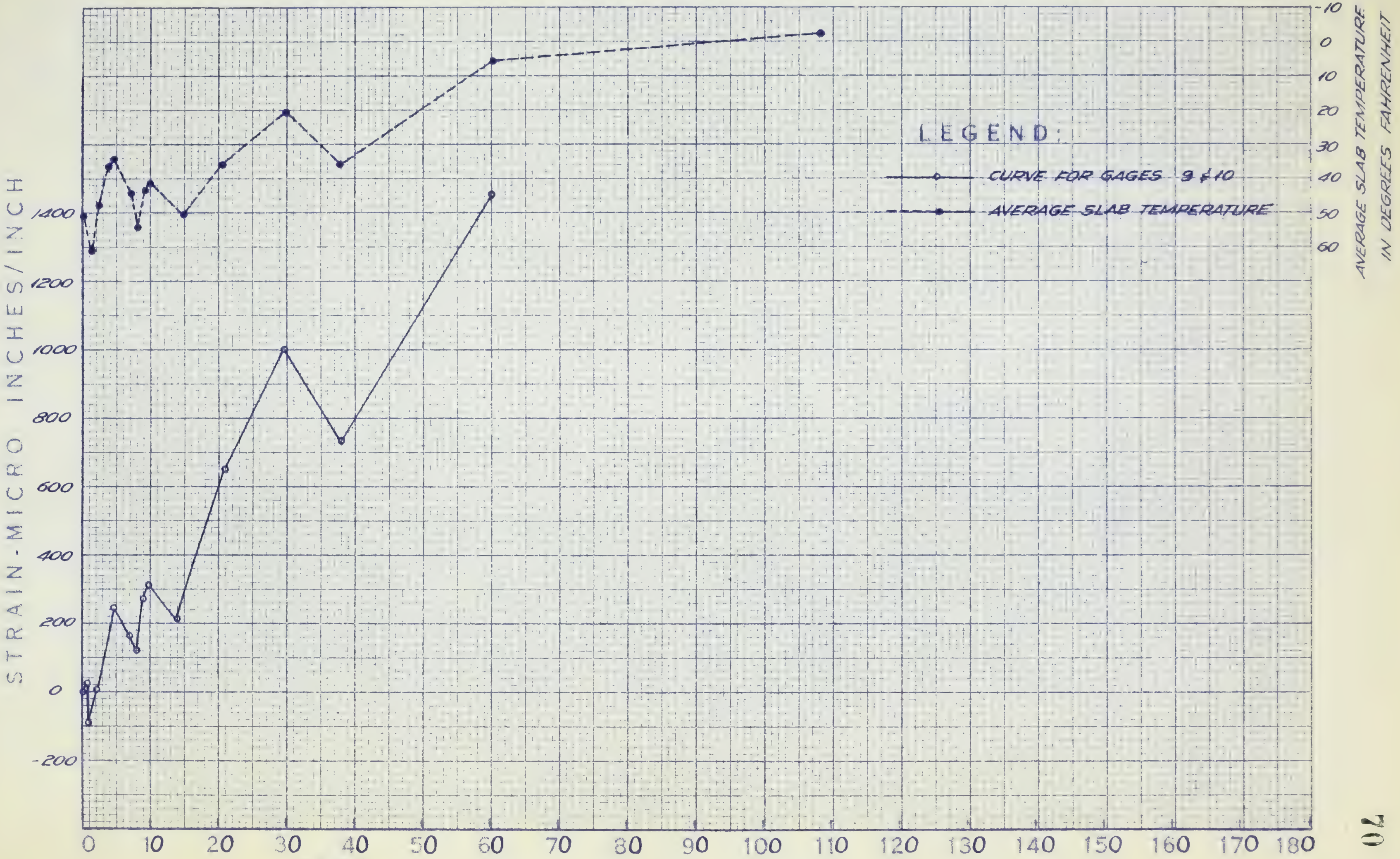


PLATE *3-2*

STRAIN TIME CURVES

SECTION TYPE B7-1 LOCATION III STATION 334+00

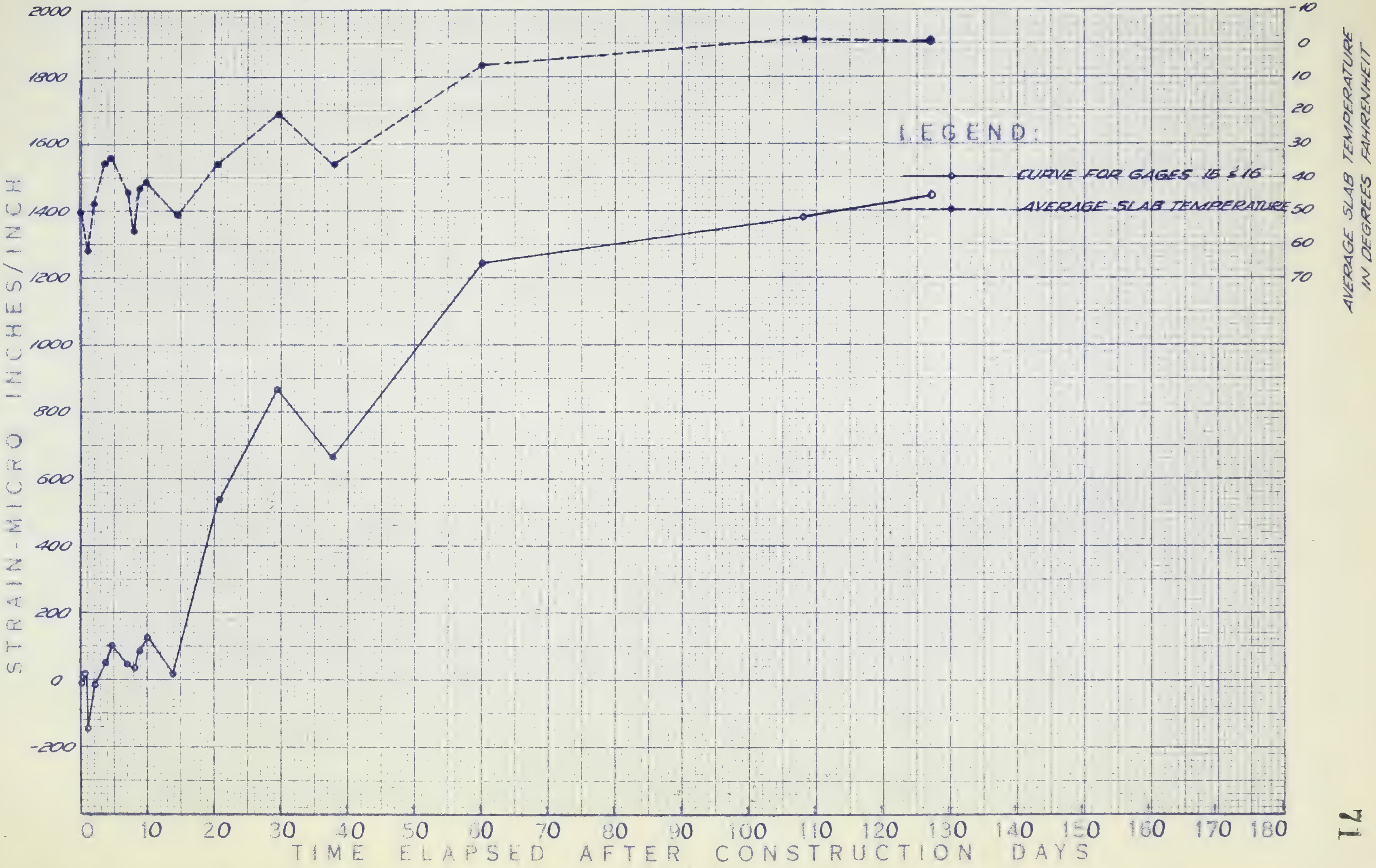


PLATE 3-3

STRAIN TIME CURVES

SECTION TYPE B7-1 LOCATION III STATION 334+00

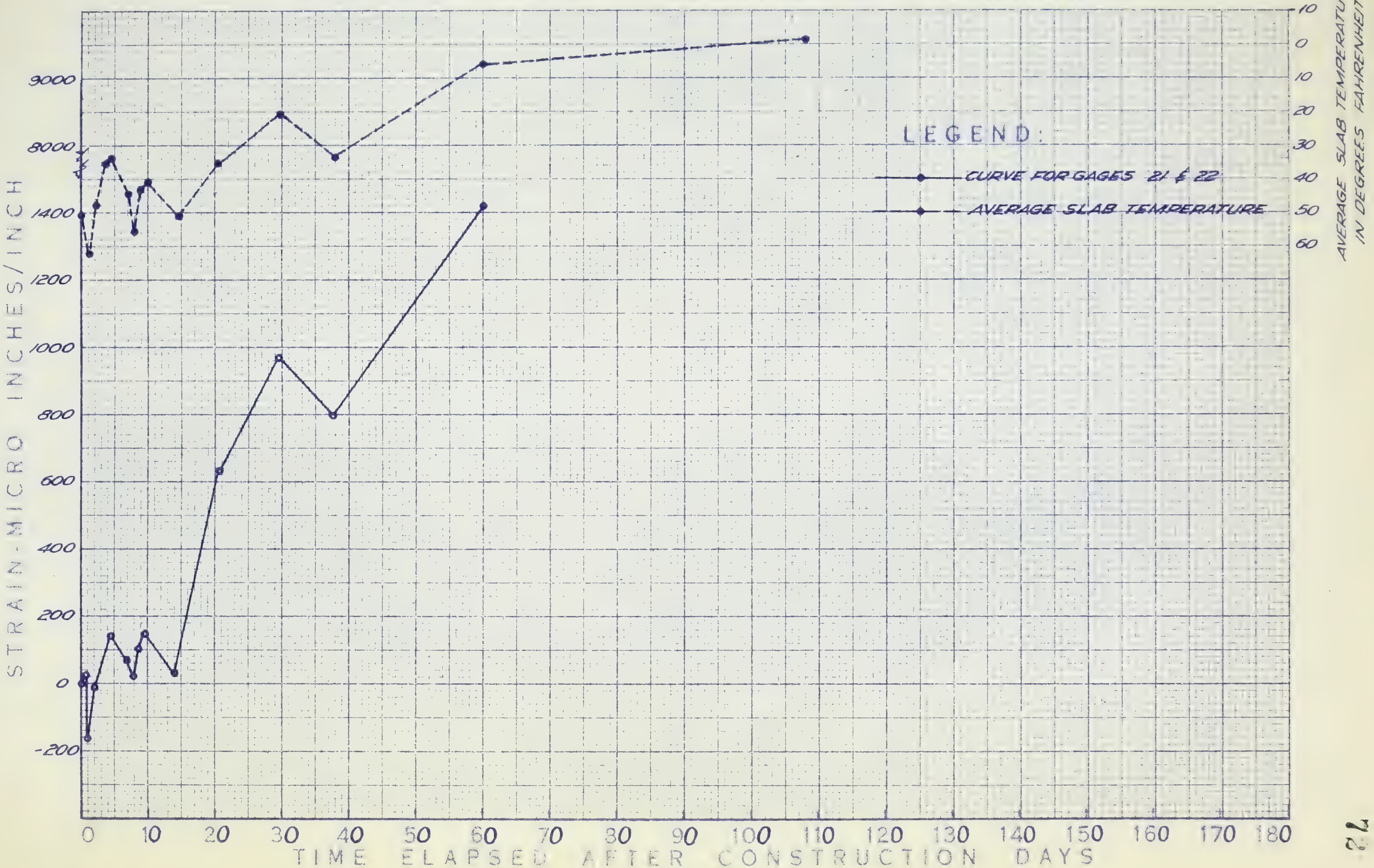


PLATE 3-4

STRAIN TIME CURVES

SECTION TYPE B7-1 LOCATION III STATION 334+00

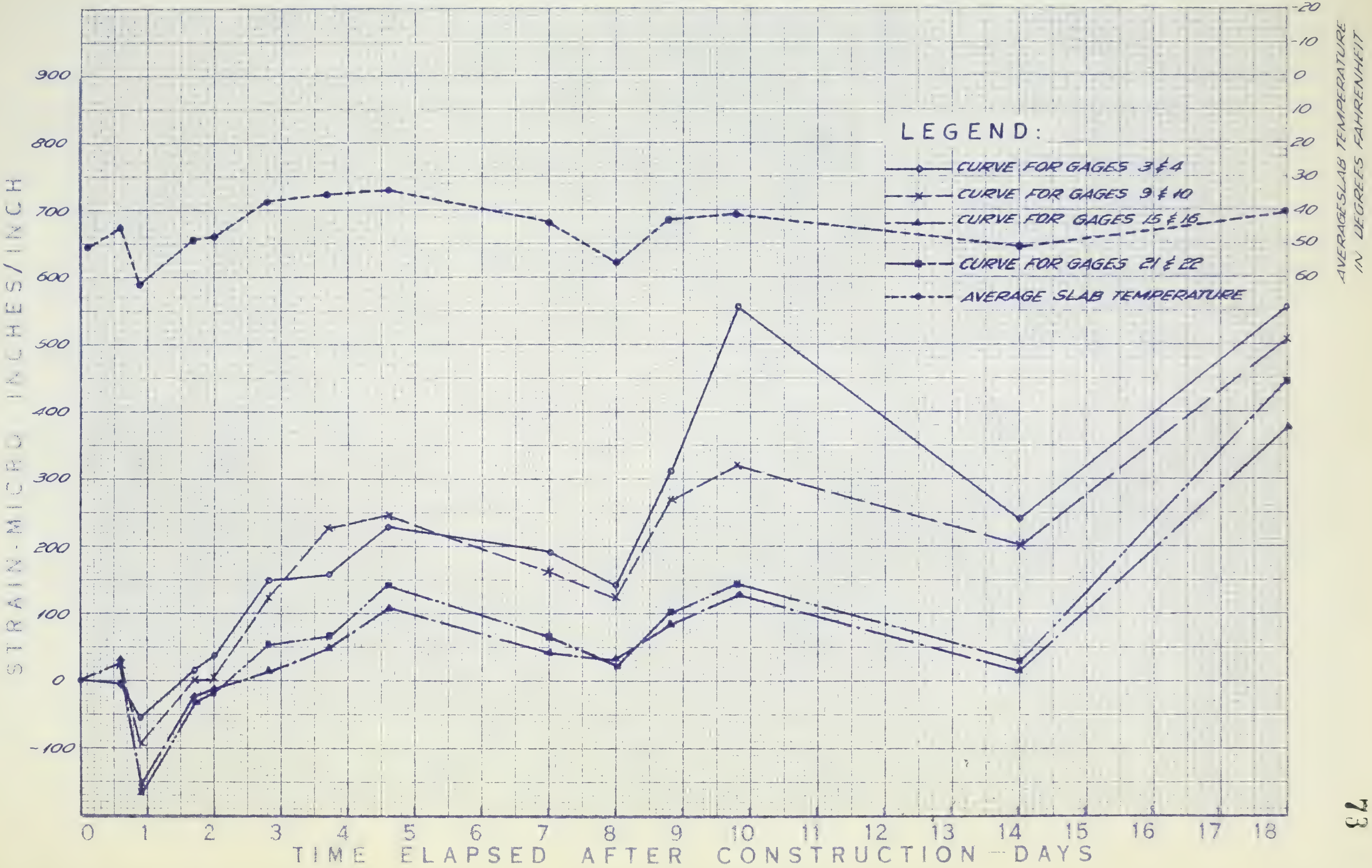


PLATE 3-5

STRAIN TIME CURVES

SECTION TYPE B7-1 LOCATION III STATION 334+00

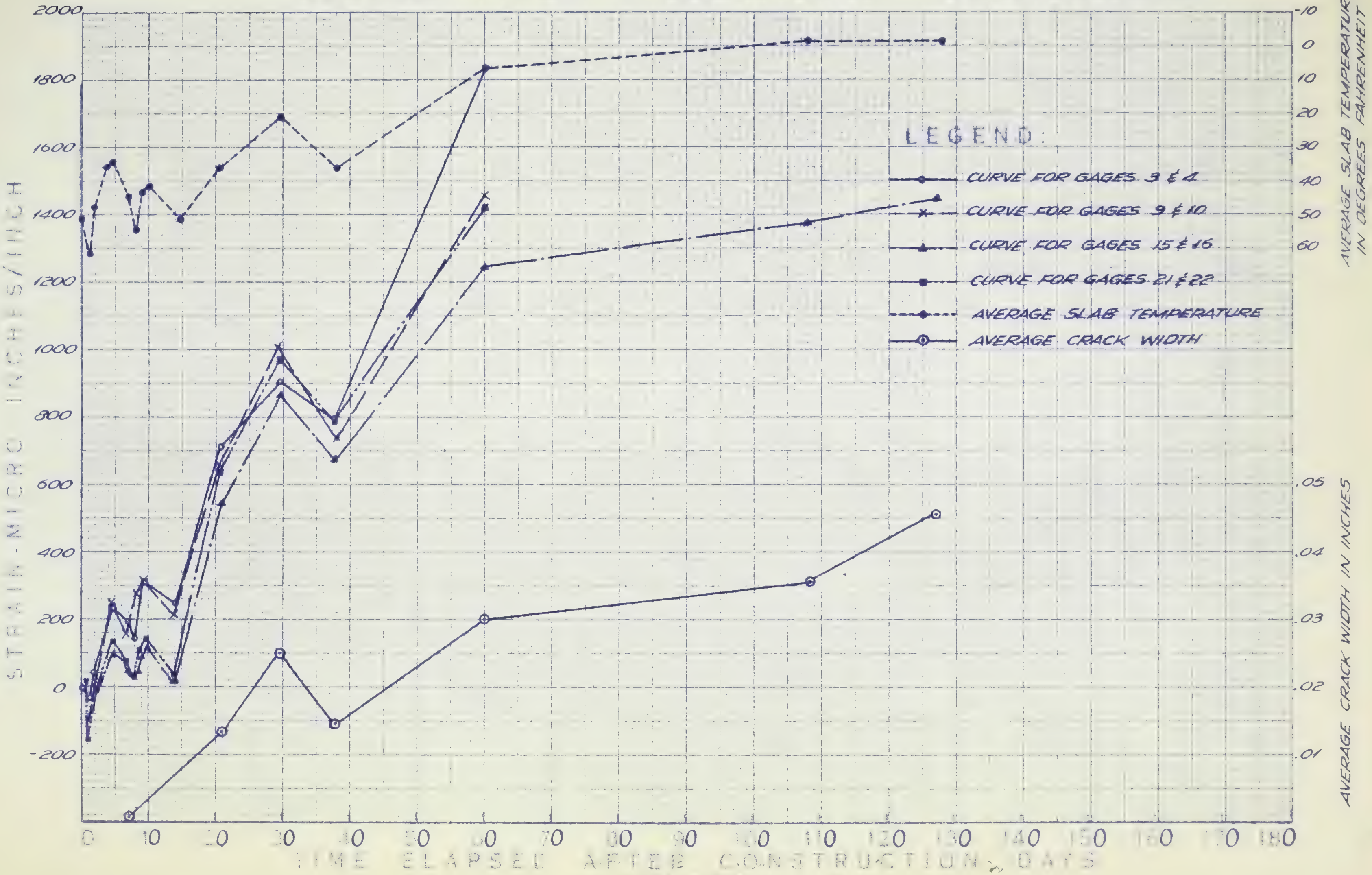


PLATE 3-6

STRAIN—TIME CURVES

SECTION TYPE *B7-1* LOCATION *III* STATION *334+00*

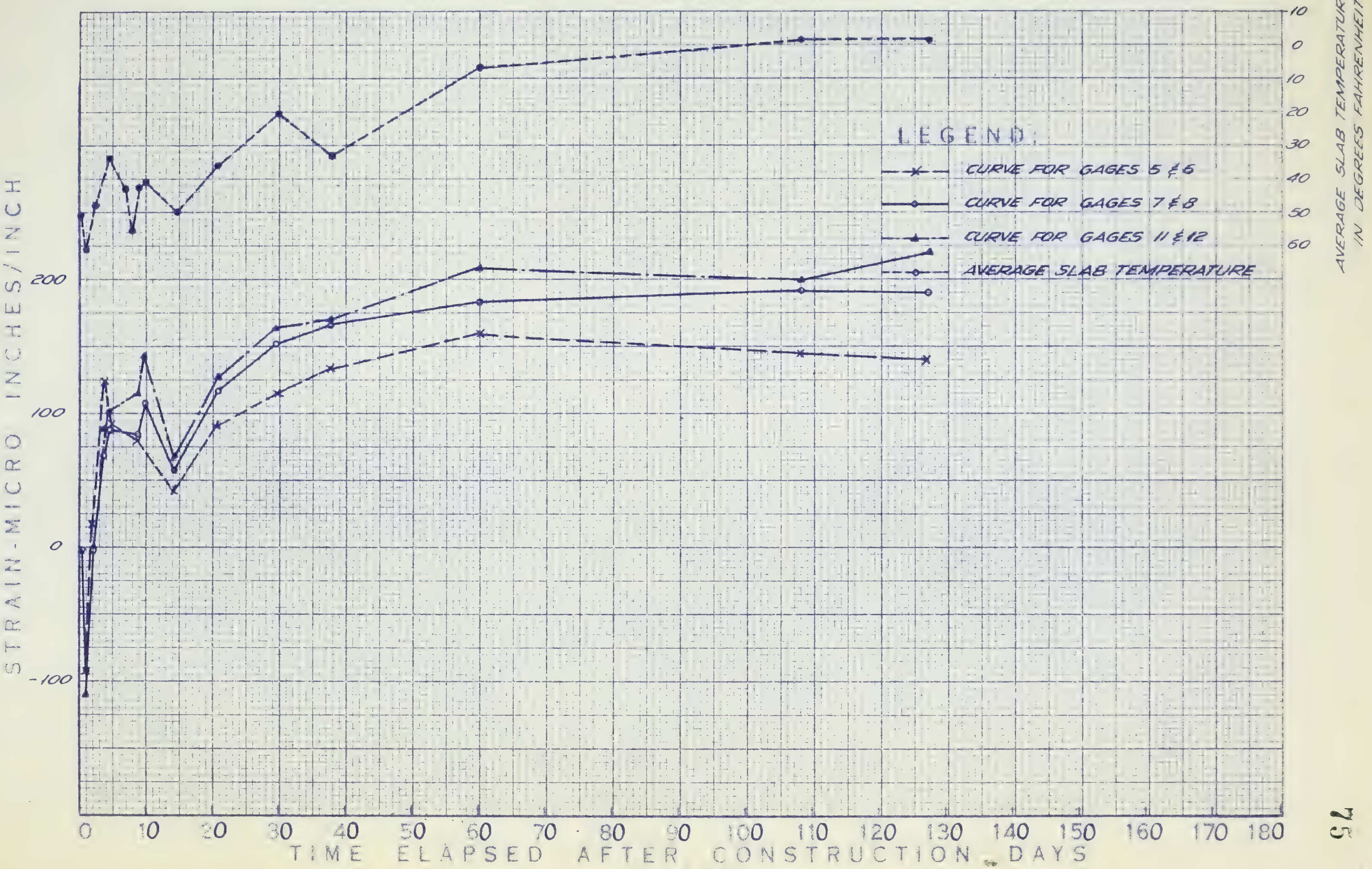


PLATE 3-7

STRAIN TIME CURVES

SECTION TYPE B7-1 LOCATION III STATION 334+00

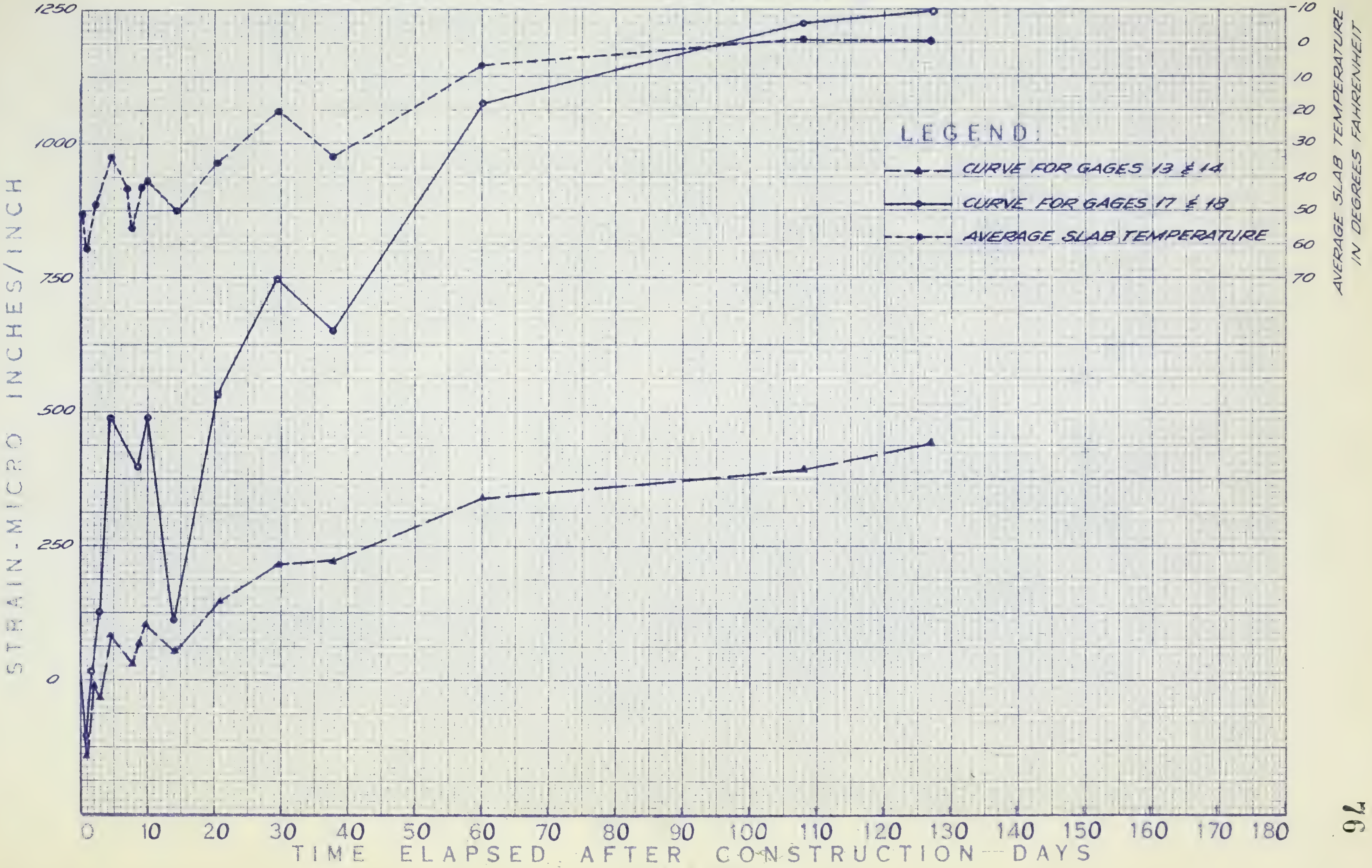


PLATE 3-8

STRAIN TIME CURVES

SECTION TYPE B7-1 LOCATION III STATION 334+00

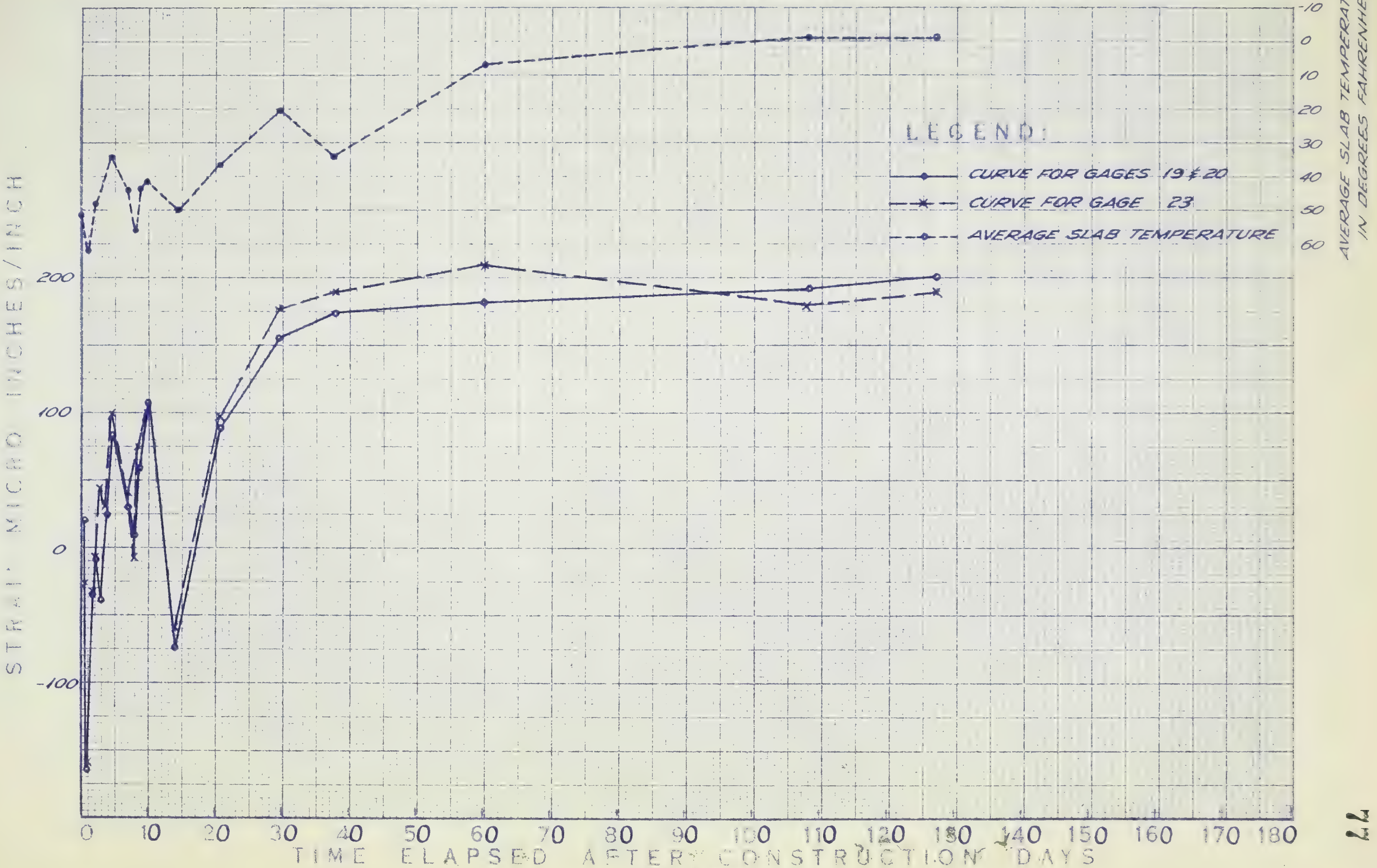


PLATE 3-9

STEEL STRAIN - CRACK WIDTH CURVE

SECTION TYPE B7-1 LOCATION III STATION 334+00

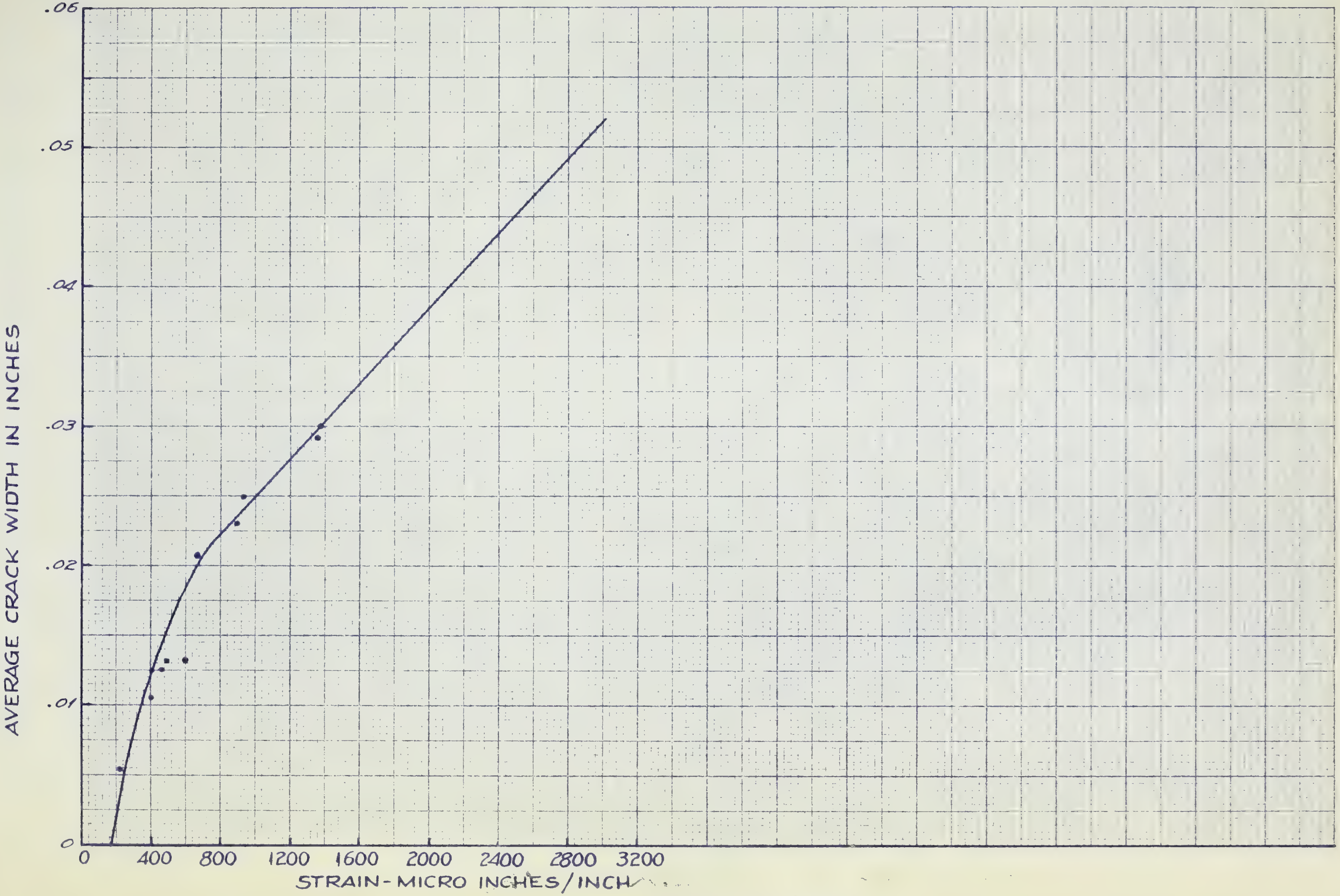


PLATE 3-10

TEMPERATURE - CRACK WIDTH CURVE

SECTION TYPE B7-1 LOCATION III STATION 334+00

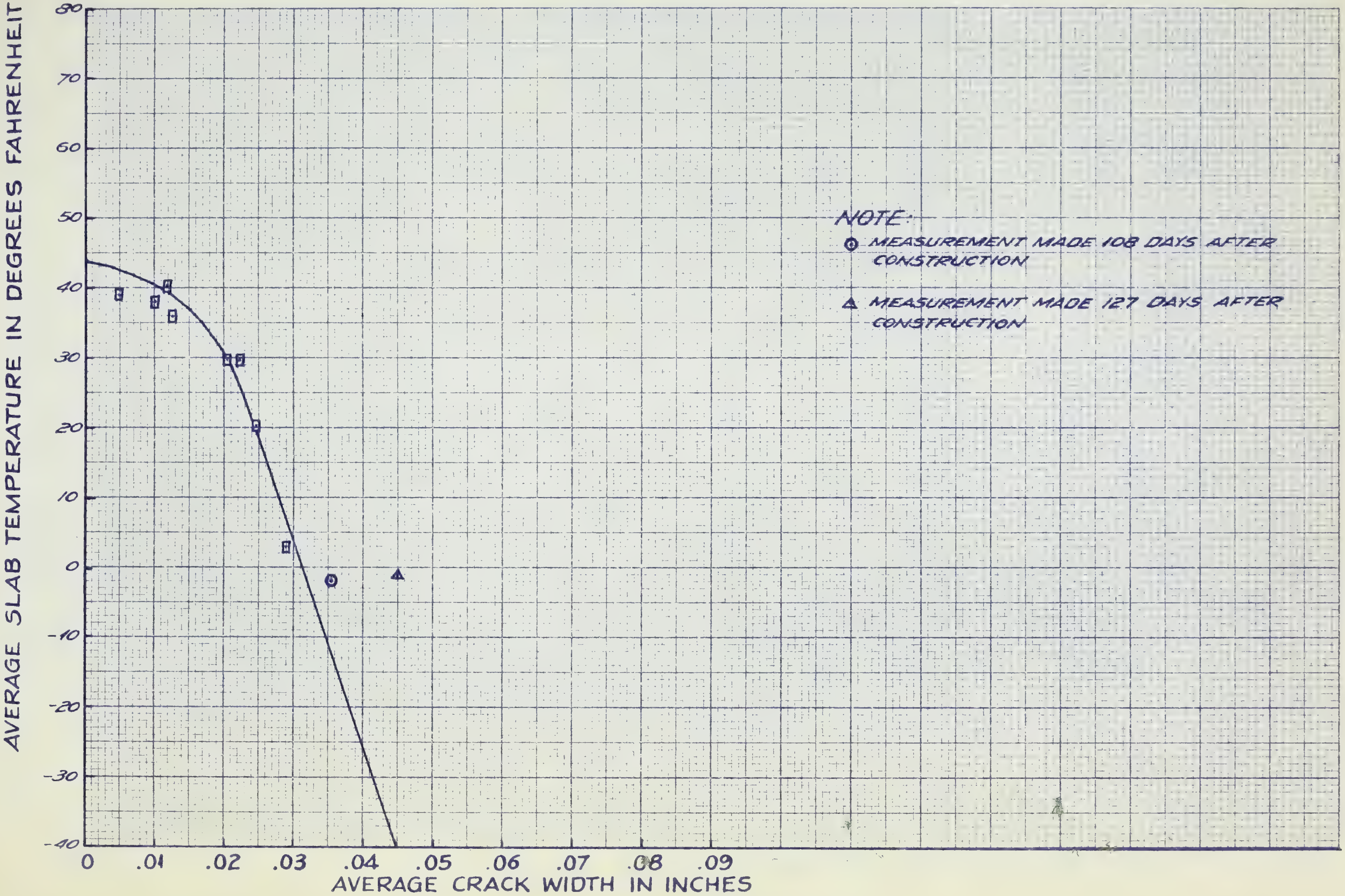
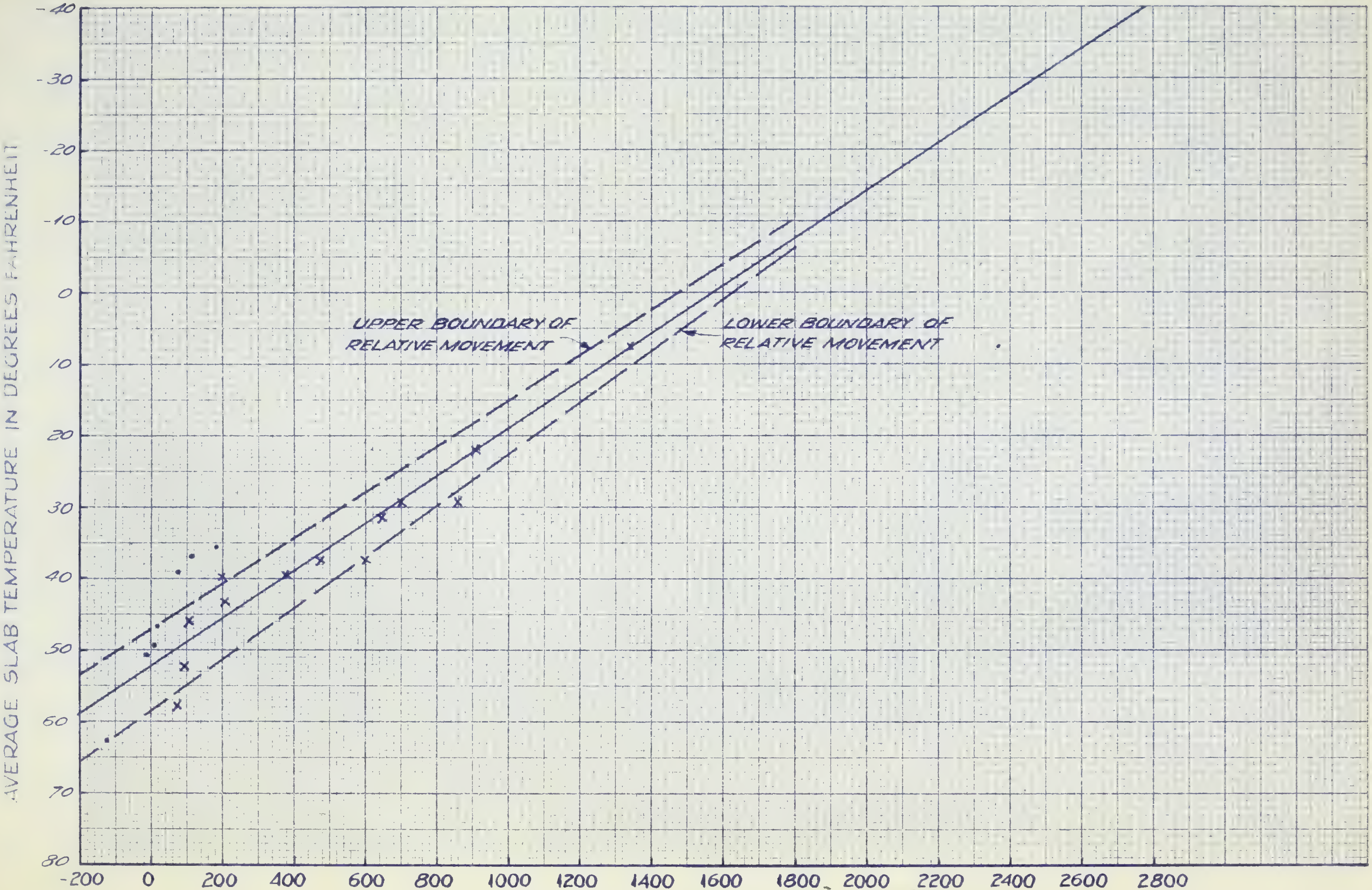


PLATE 3-11

STEEL STRAIN - AVERAGE SLAB TEMPERATURE CURVE

SECTION TYPE 87-1 LOCATION III STATION 334+00



STRAIN - MICRO INCHES/INCH

PLATE 3-12

STRAIN TRANSFER DISTRIBUTION CURVES

SECTION TYPE B7-1 LOCATION III STATION 334+00

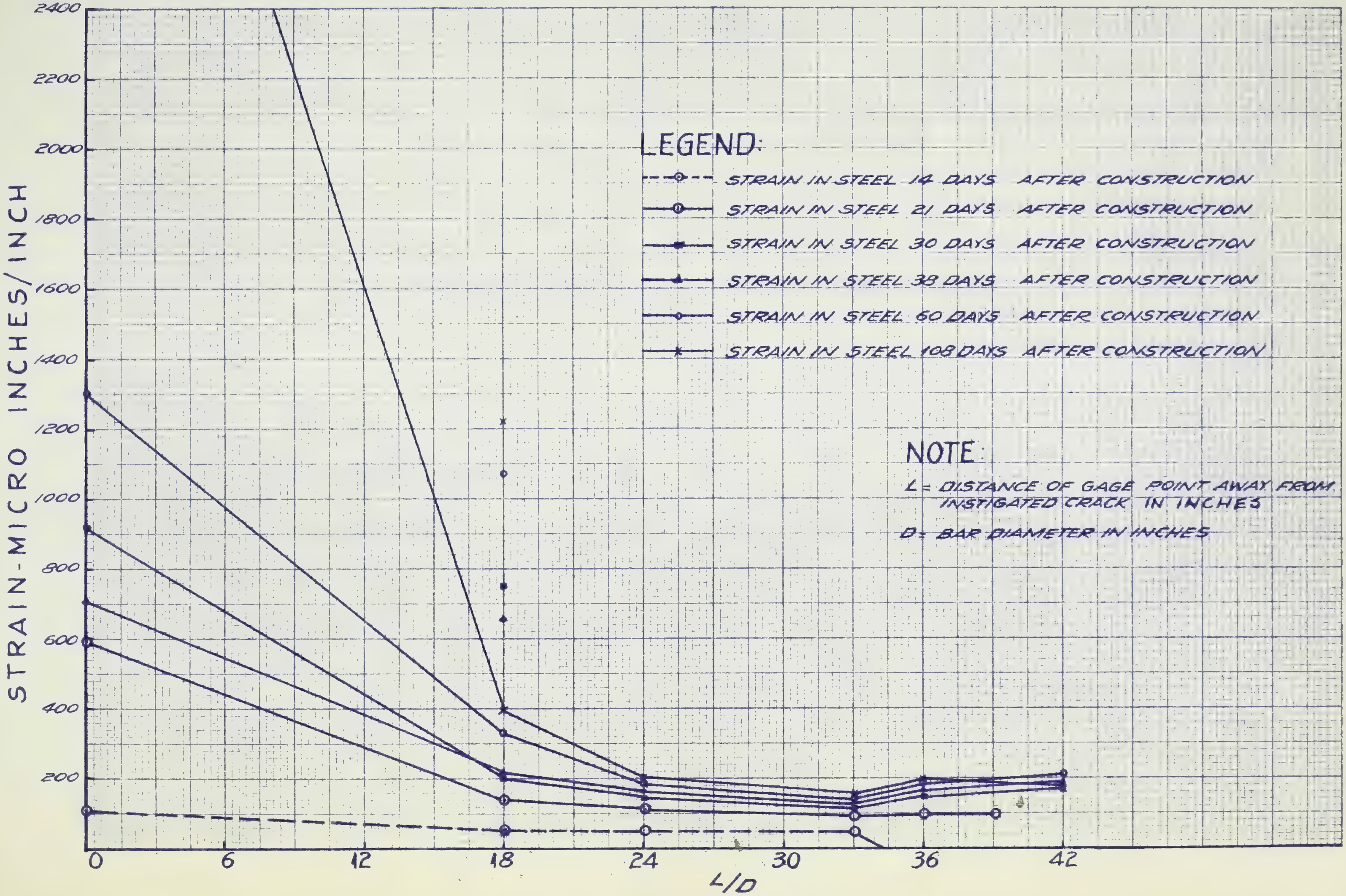


PLATE 3-13

SECTION TYPE B

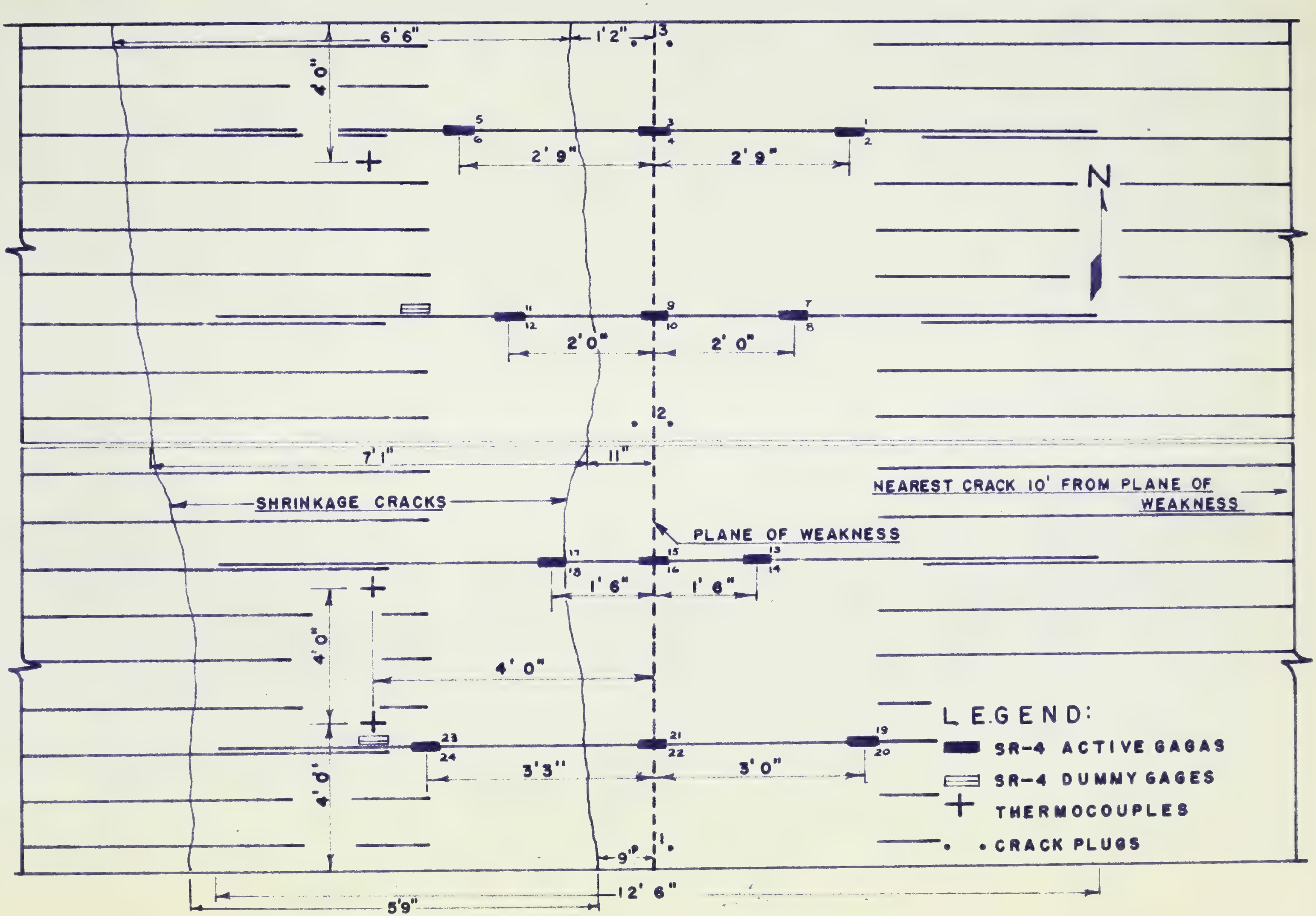


PLATE 3-14

3. Section Type B6-1

The reinforced concrete pavement Type B6-1, 1,972 feet in length, consists of a six inch slab continuously reinforced with No. 6 intermediate grade deformed steel bars comprising a 0.715% cross-section area of the pavement (Plate 4).

Prepared bars were placed at four cross-sections in this test strip. Full consideration was given in selection of a suitable location for gage installations. For the purpose of comparison, Locations IV and V were selected on the test strip where there was a cut of one foot while Locations VI and VII were selected to be on a fill of six feet. The plan and the profile of the test road are shown in Plate 6.

(a) Location IV

Concrete was placed in the test section at 8 a.m. on October 15, 1958. First set of readings was taken three hours after the finishing operation.

The strain history in the reinforcing steel at the plane of weakness is shown in Plate 4-1 and 4-2. Strain history at gage points on each side of the plane of weakness is shown in Plates 4-3 and 4-4. The diagram in Plate 4-5 shows the position of gages in the test section, and also the location of the shrinkage crack which developed before the plane of weakness was induced.

The presence of the shrinkage crack coupled with a probable bending action explains the strange strain pattern in the reinforcing steel at the plane of weakness and at gage points on each side, (Plates 4-1 to 4-4).

The crack width measurements indicate that the slab did not crack at the plane of weakness. Therefore, strain measurements at gage points located at the plane of weakness do not truly represent the strain condition in the reinforcing steel at the crack but at some distance from it.

Strain measurements indicate that the reinforcing steel at the crack began to yield in the south lane before the pavement was 51 days old. It is probable that the reinforcing bars started to yield 41 days after construction when a low of -13°F. was recorded at the Calgary airport.

It should be pointed out that the crack width measurement taken on February 10, 1959 showed that the crack had opened to 0.0445 inches at the north edge of the pavement when the slab temperature was -3°F. The crack width measurements at the north edge of the pavement are questionable because the crack passed through one of the gage points.

Due to the irregular strain pattern in the reinforcing steel at the plane of weakness, and due to the uncertain width of the shrinkage crack, no relationship between strain in the reinforcing steel, crack width and temperature, could be established.

The last strain and temperature measurements were made on December 5, 1958. Subsequent to this date water entered the terminal box preventing further measurements.

STRAIN—TIME CURVES

SECTION TYPE B6-1 LOCATION IV STATION 311+50

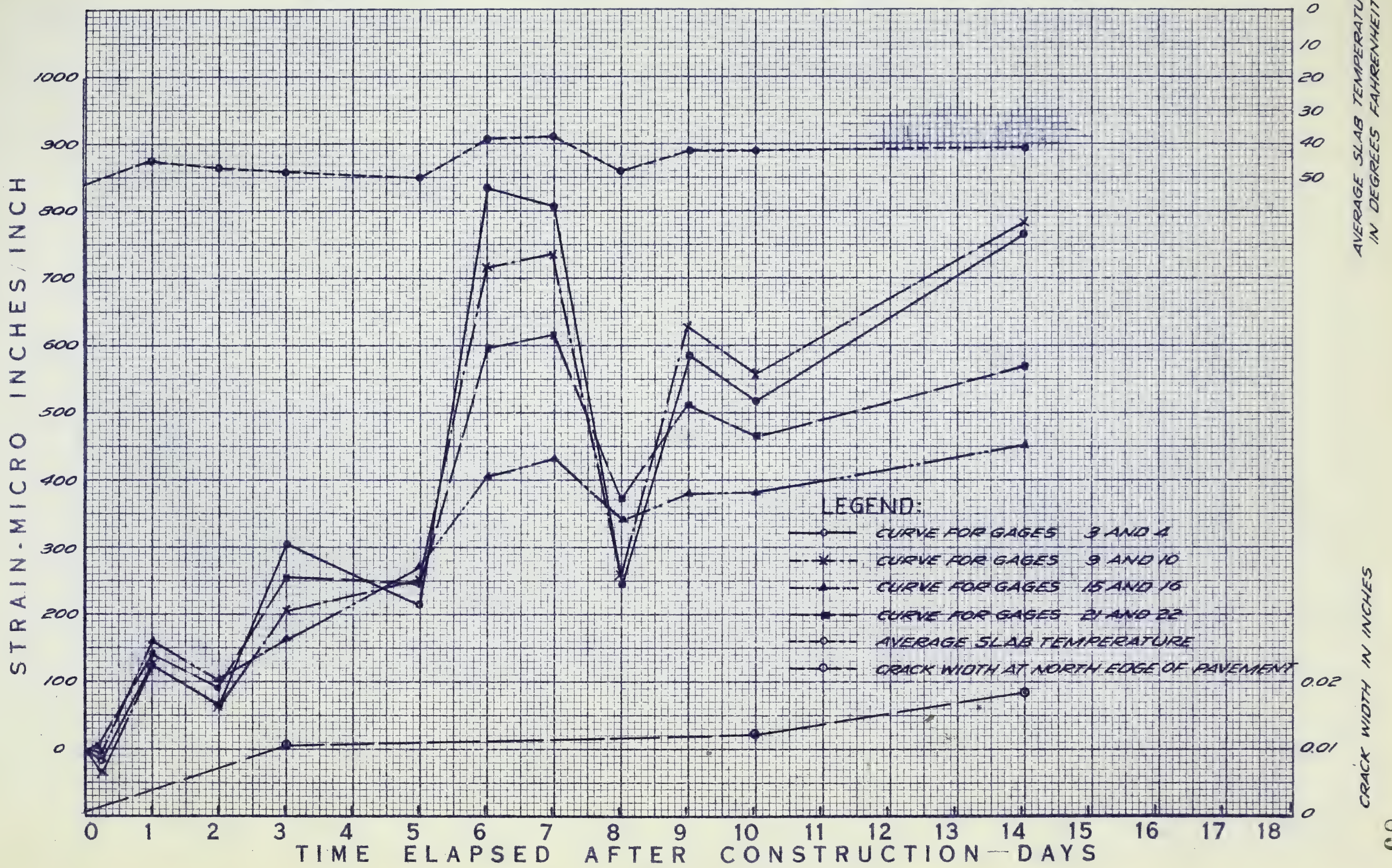


PLATE 4-1

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION IV STATION 311+50

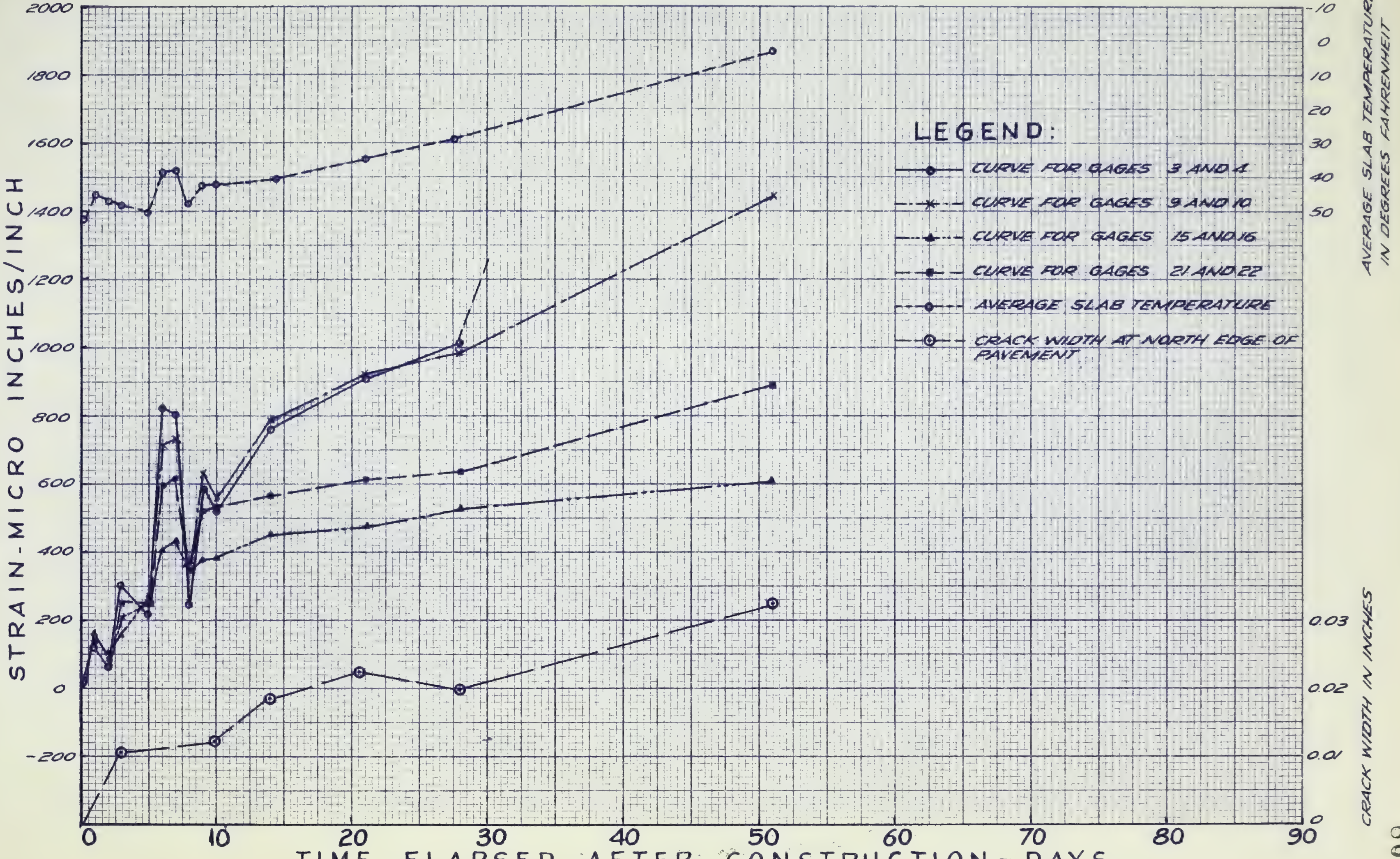


PLATE 4-2

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION IV STATION 311+50

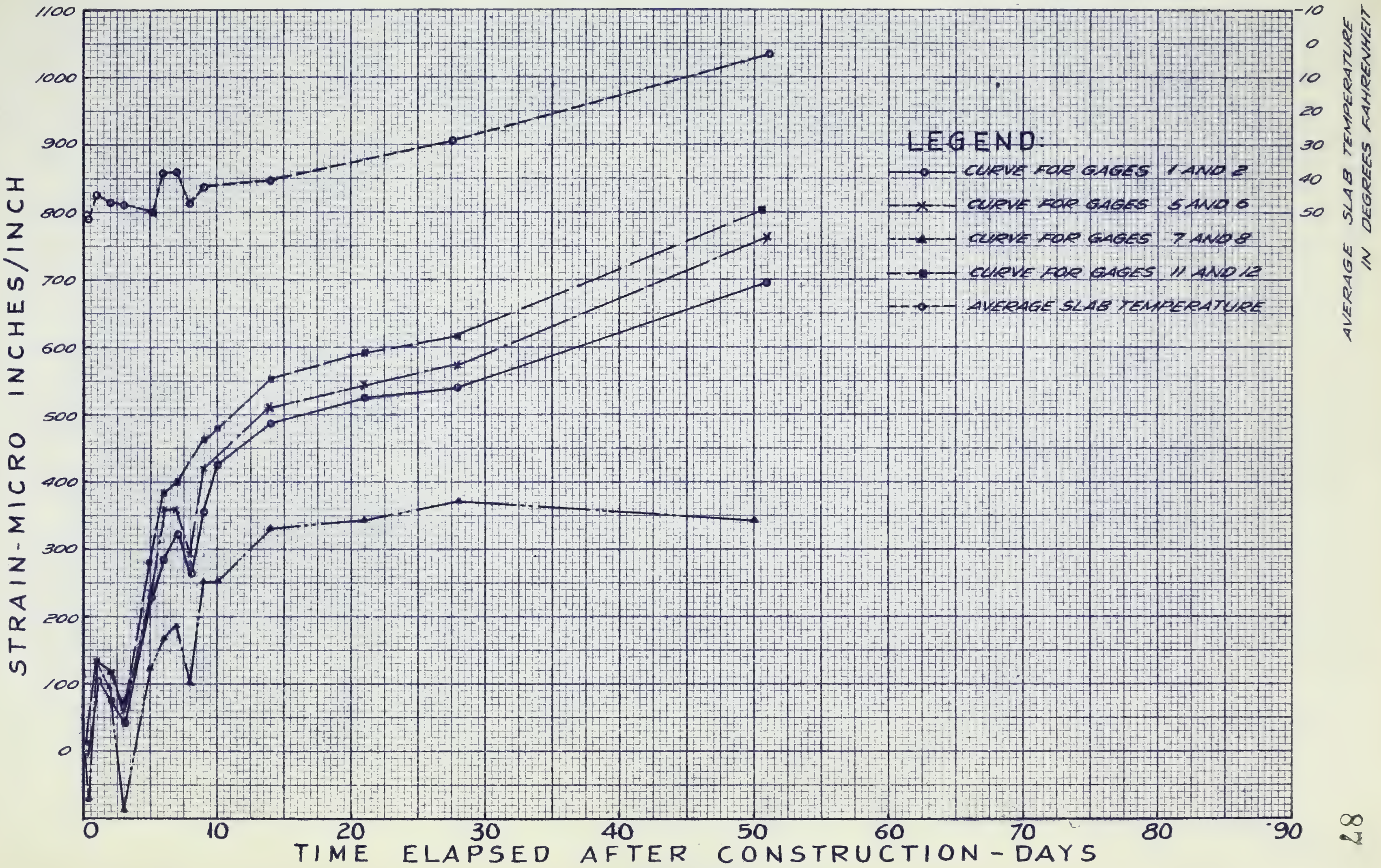


PLATE 4-3

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION IV STATION 311+50

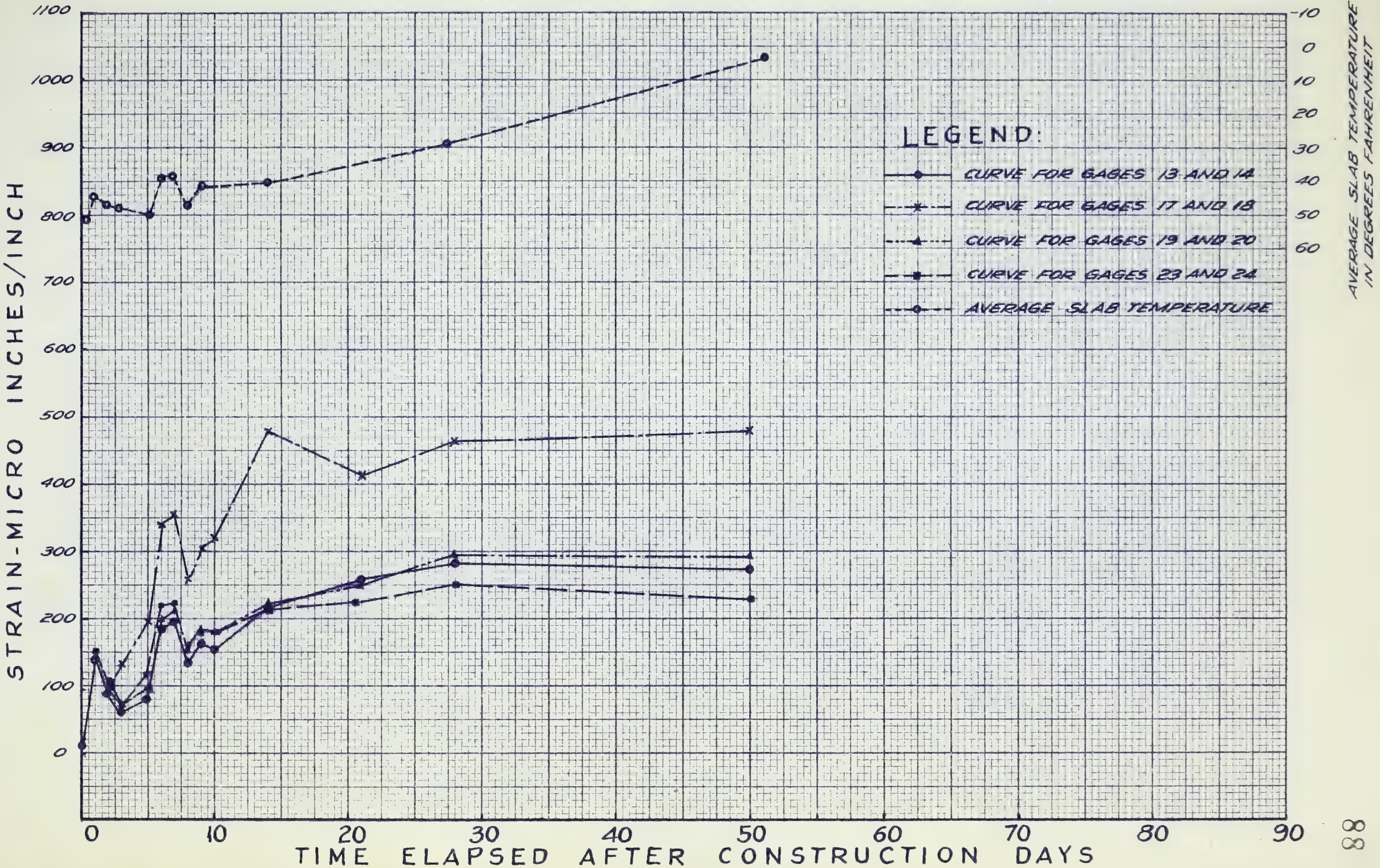


PLATE 4-4

SECTION TYPE B6-1

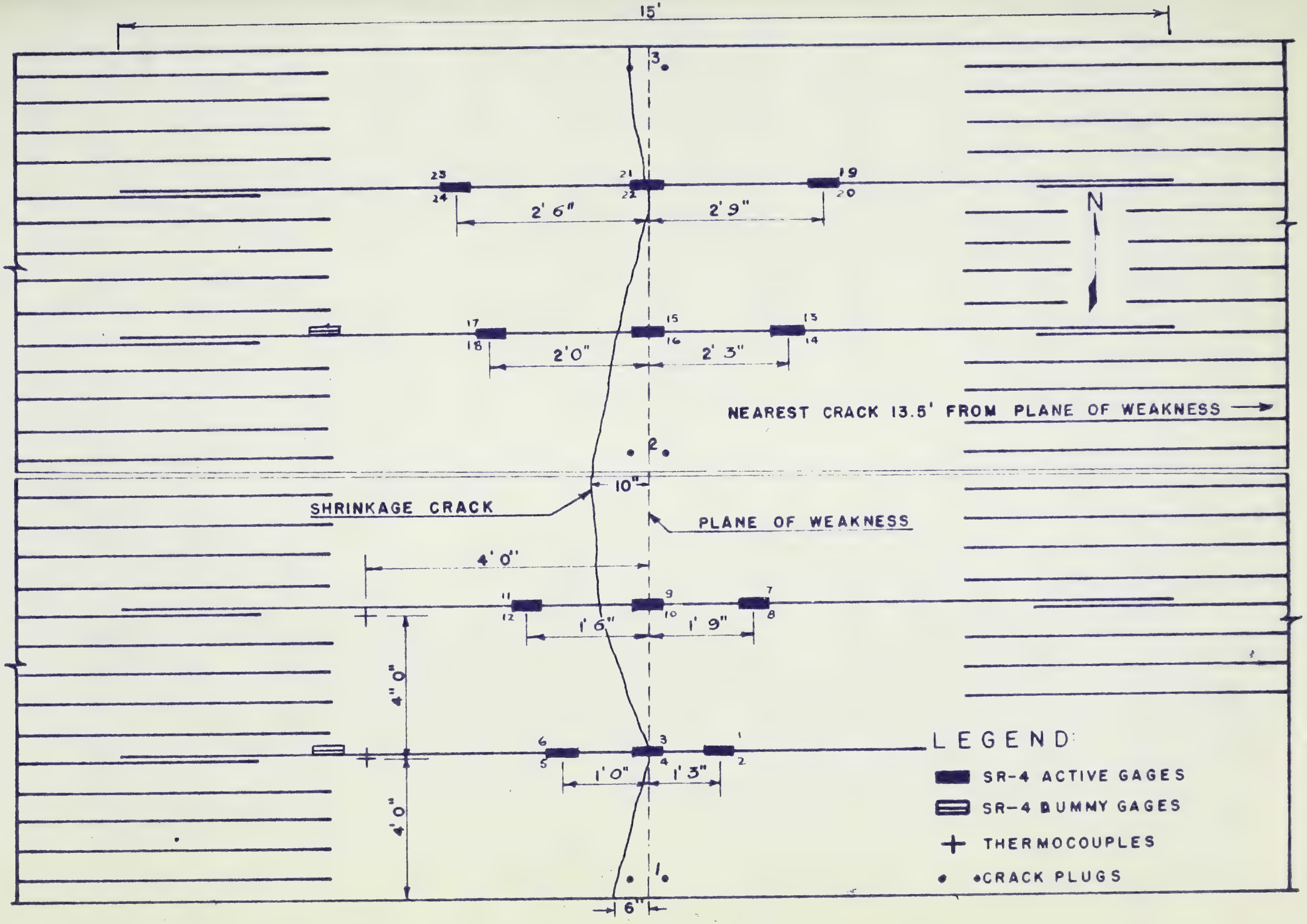


PLATE 4-5

(b) Location V

The pavement was placed at the test section at 7 a.m. on October 16, 1958 when the temperature was 34°F. Gage readings taken about two hours after the surface finishing operation provided the basis for all subsequent measurements.

The strain history in the reinforcing steel at the instigated crack is shown in Plate 5-1. The strain history for gage points located at each side of the crack is shown in Plates 5-2 to 5-5 inclusive. Diagram in Plate 5-6 shows the gage positions and the location of the shrinkage crack.

An examination of the strain-time curves in Plate 5-1 reveals that the prepared bars in the north lane of the pavement were subjected to considerably larger strains at the plane of weakness than in the south lane.

Measurements taken on November 6, 1958 when the pavement was 28 days old indicate that the prepared bars at the plane of weakness were strained to 1,100 micro inches/inch in the north lane of the pavement and 700 micro inches/inch in the south lane when the slab temperature was 30°F. The crack at the north edge of the pavement opened to 0.021 inches.

This was the lowest temperature at which readings were made on the gages before the prepared bars yielded in tension. Measurements were made on December 5, 1958 when the pavement was 50 days old and the slab temperature was 5°F. The crack width at the north edge of the pavement had increased to 0.043 inches and the reinforcing bars at the crack were strained to 9,000 micro inches/inch, or far beyond the yield point.

Good relationship seems to have existed between strain in the reinforcing steel, crack width and slab temperature during the first four weeks of pavement life. However, insufficient data are available at this location to establish definite trends.

Curves in Plates 5-2 and 5-3 indicate compression in the reinforcing bars at gage points 1-2, 7-8 and 11-12. Compressive strains at these gage points seem to increase with a decrease in temperature. No explanation for this unusual strain pattern at these gage points is available at the present time.

An examination of curves in Plates 5-4 and 5-5 reveals that almost identical strain pattern existed in the reinforcing steel at gage points away from the plane of weakness in the north lane.

Conclusions

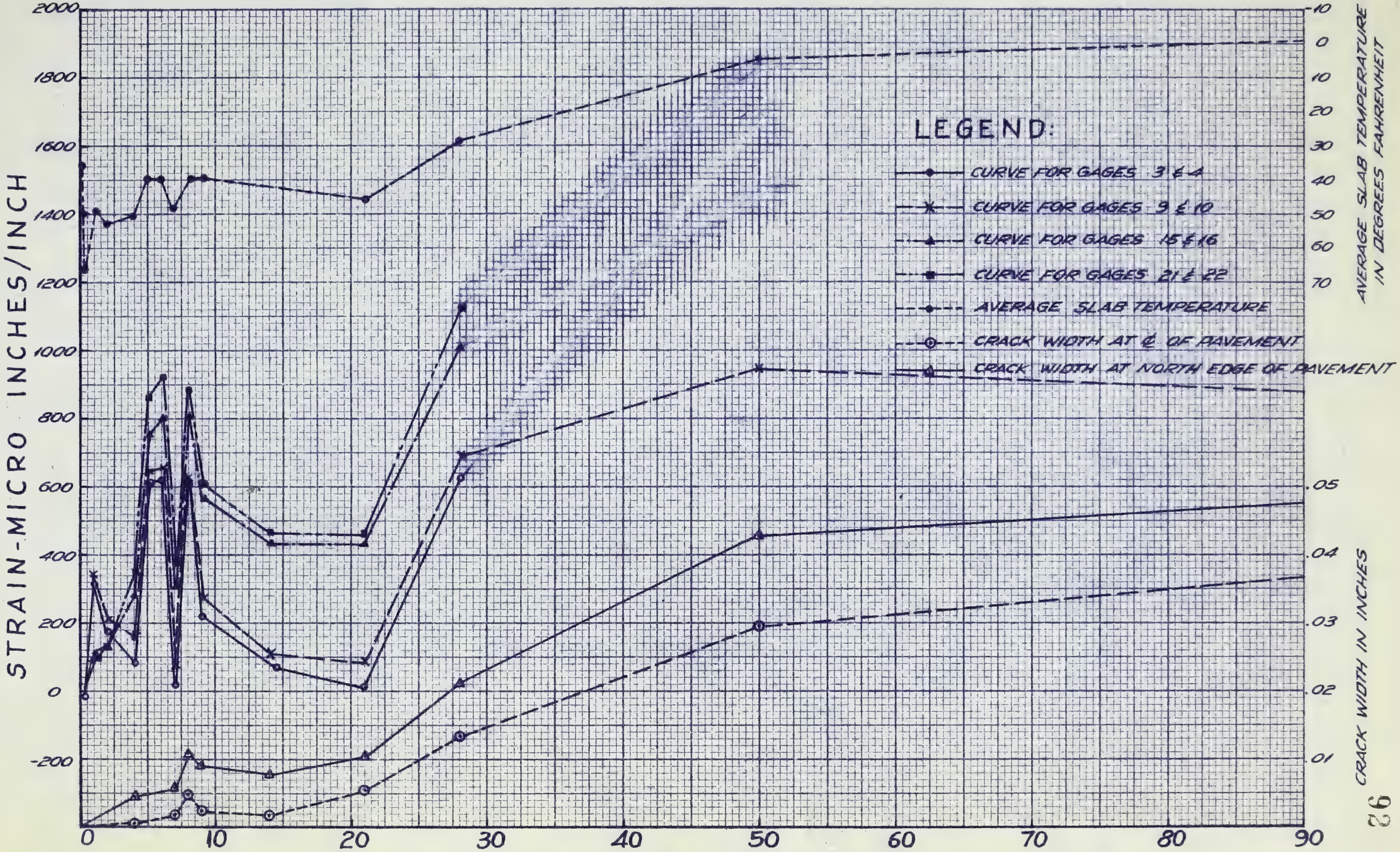
Reinforcing bars yielded at the crack when concrete pavement was between 28 and 50 days old. Sufficient data are unavailable to determine the approximate temperature range at which yielding started.

Considering the strain history in the reinforcing steel for the first four weeks of pavement life, yielding probably started in the steel embedded in the north lane of the pavement.

Due to unusual strain behaviour at gage points at each side of the plane of weakness, it is not possible to determine the length over which the loss of bond extended.

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION V STATION 307+00



TIME ELAPSED AFTER CONSTRUCTION - DAYS

PLATE 5-1

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION V STATION 307+00

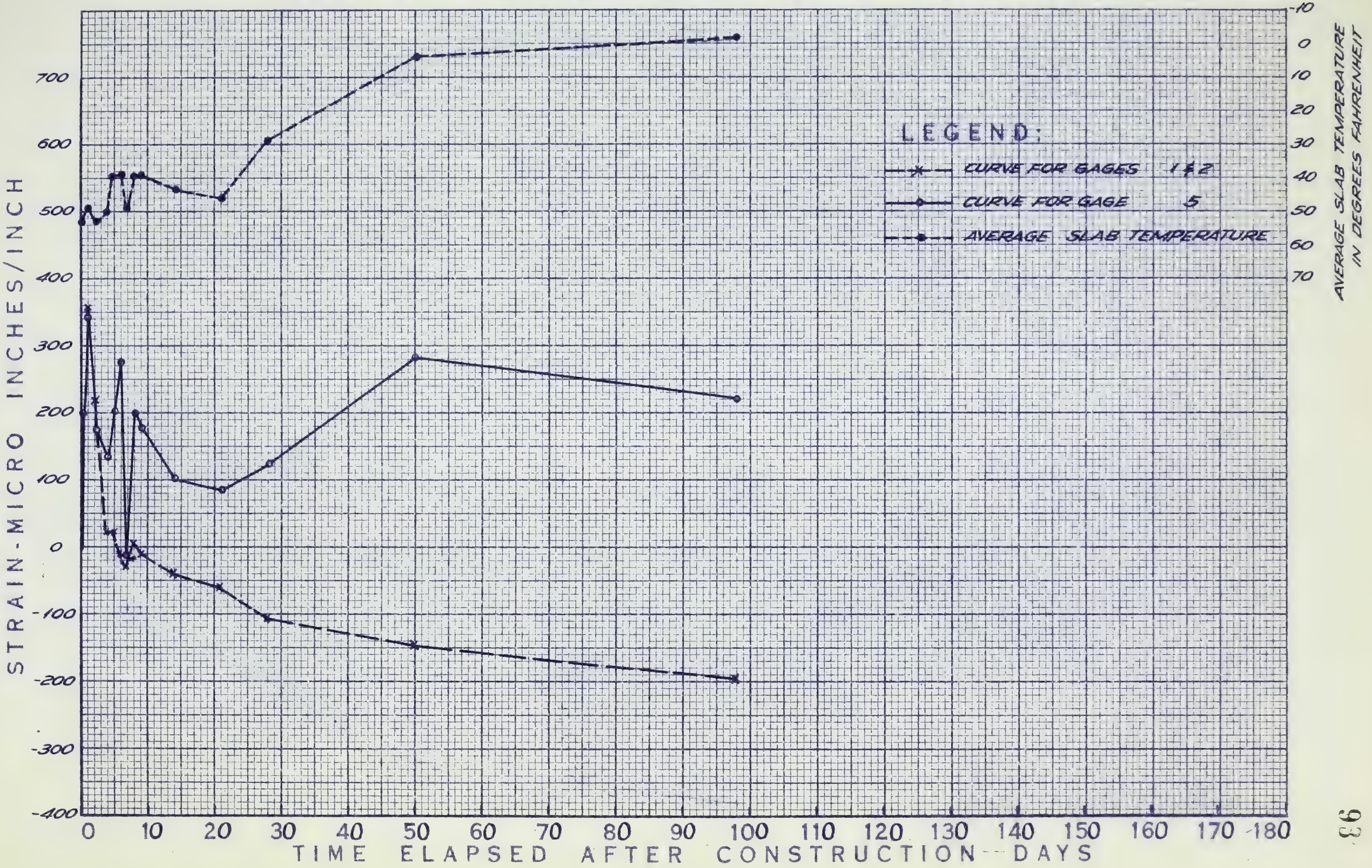


PLATE 5-2

STRAIN—TIME CURVES

SECTION TYPE B6-1 LOCATION V STATION 307+00

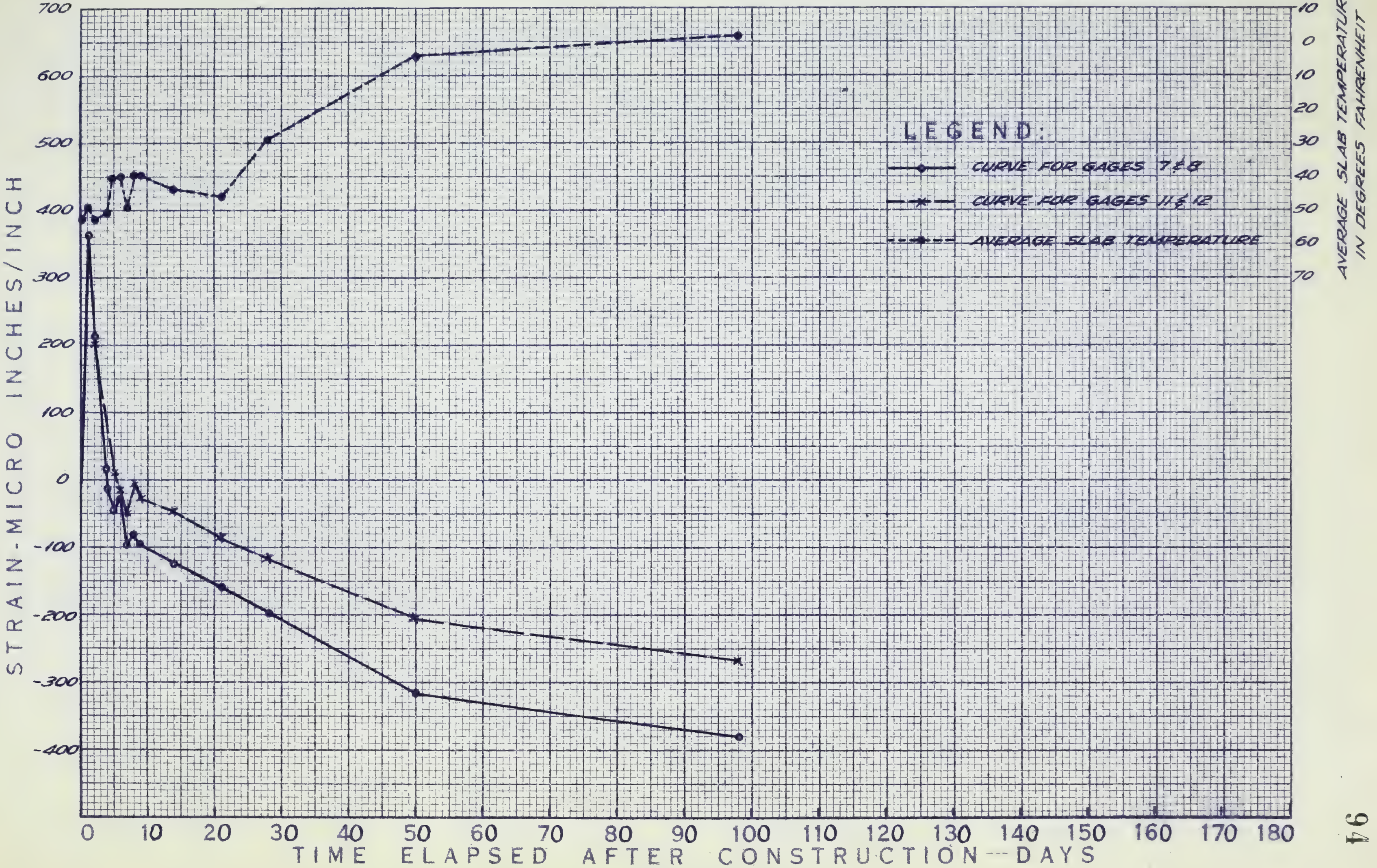


PLATE 5-3

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION V STATION 307+00

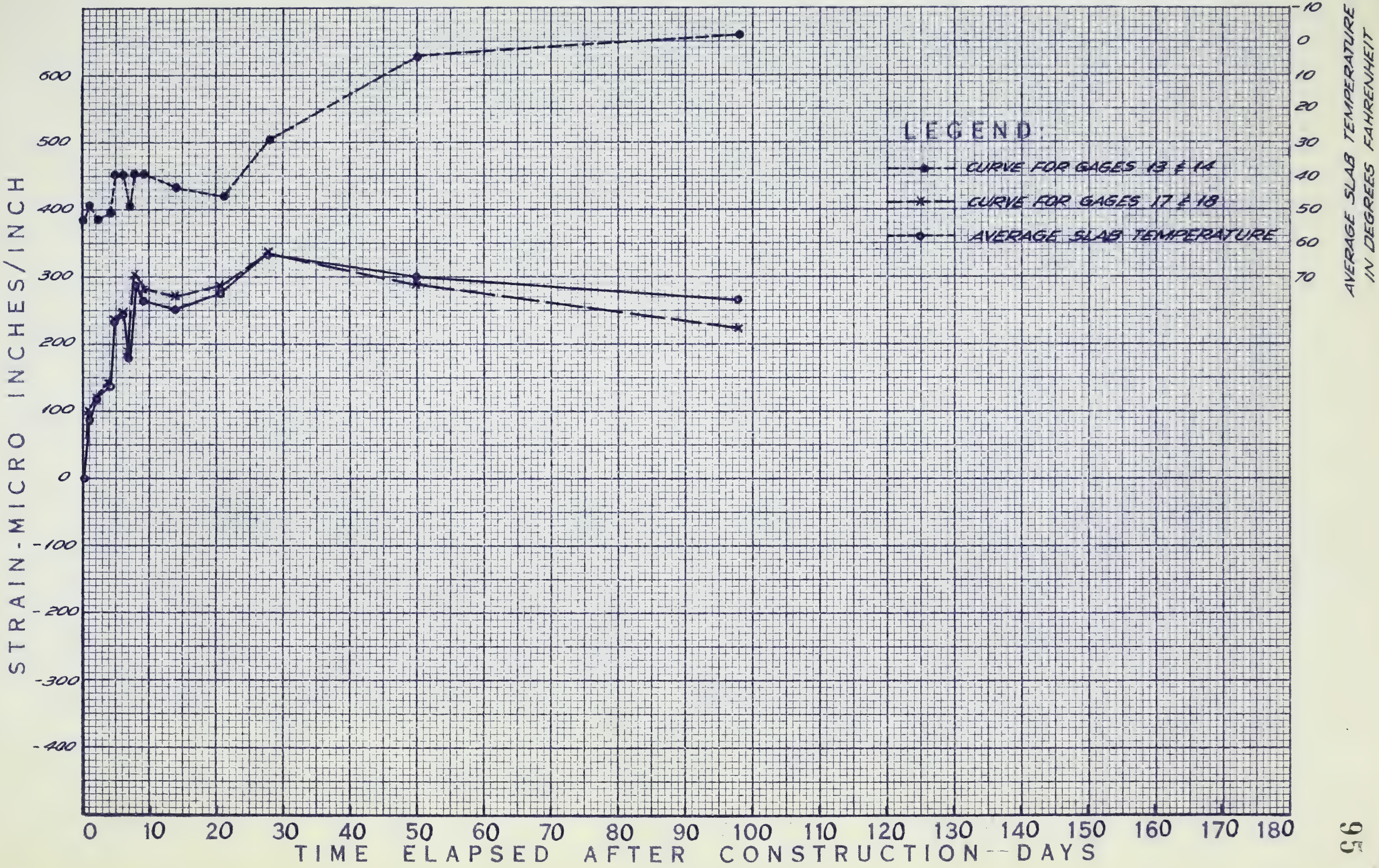


PLATE 5-4

STRAIN TIME CURVES

SECTION TYPE B6-1 LOCATION V STATION 307+00

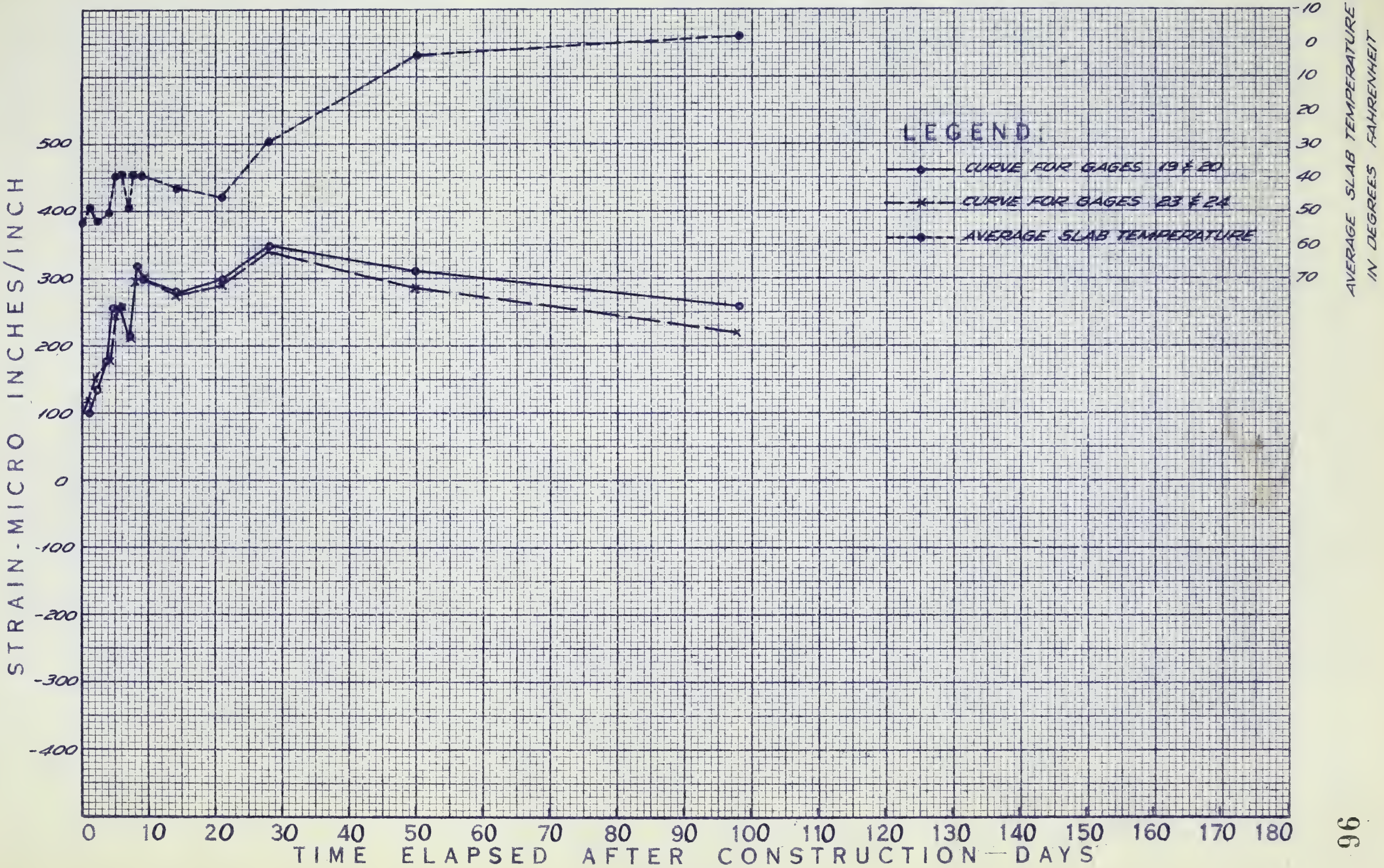


PLATE 5-5

SECTION TYPE B6-1

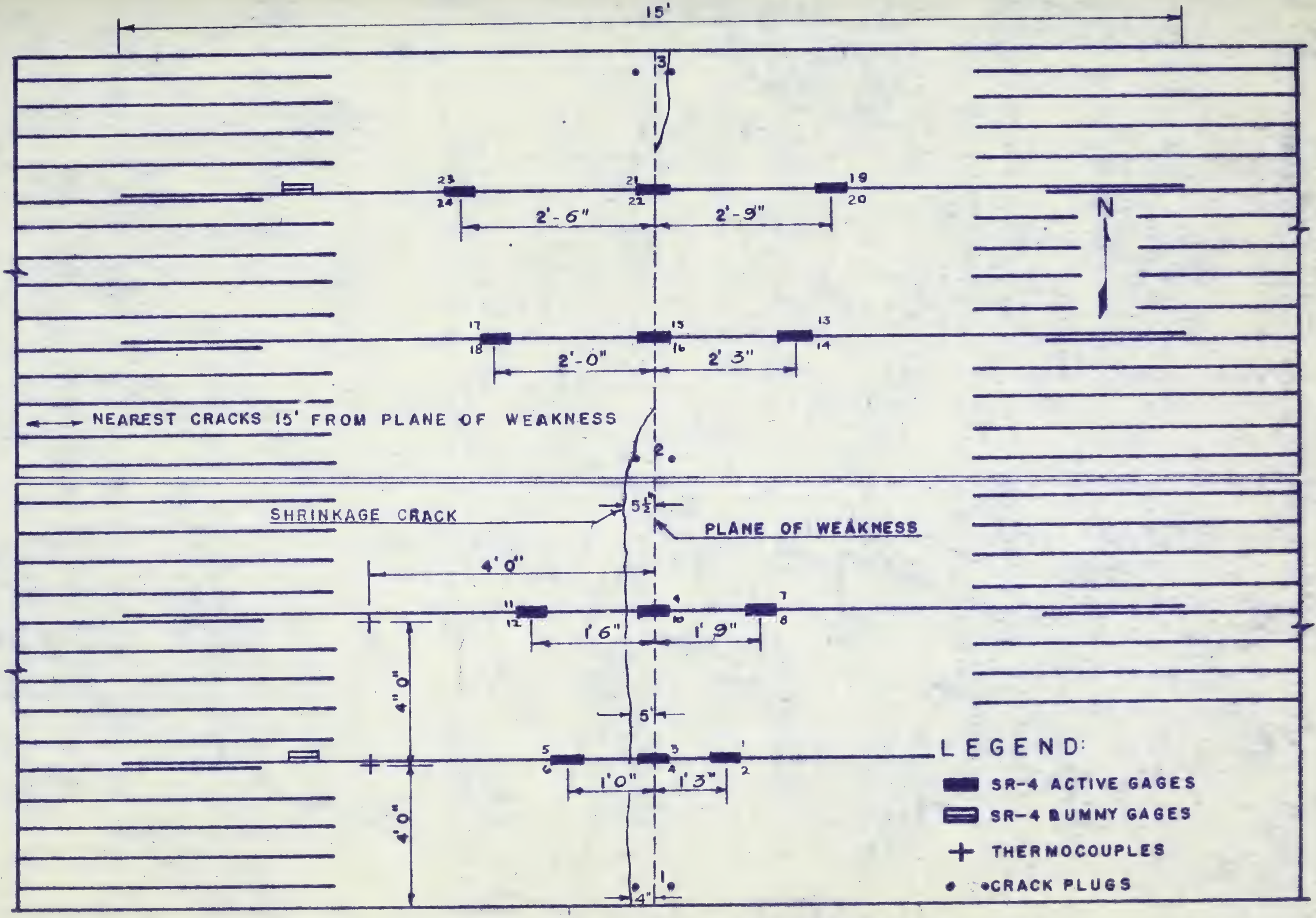


PLATE 5-6

(c) Location VI

The pavement was poured at the test section at 8.00 a.m. on October 16 of 1958. The initial readings were taken 3 hours after the finishing operations when the slab temperature was 53°F.

The strain history in the reinforcing bars at the instigated crack is shown in Plates 6-1 and 6-2, and at the gage points at each side of the plane of weakness in Plates 6-3 to 6-6 inclusive. The diagram in Plate 6-8 shows the position of the strain gages and the location of the gage points at which crack measurements were taken. Curves in Plate 6-7 show strain variation in the reinforcing steel at the instigated crack and the variation in the crack width.

The behaviour of the pavement during the first few days after pouring provided very interesting information. However, the most significant feature of the early behaviour did not become apparent for some weeks.

Curves in Plates 6-1 and 6-2 show that close relationship existed between strain in the reinforcing steel and the slab temperature.

Measurements taken four days after concrete was placed in the test section indicate that the slab cracked along the plane of weakness. The crack opened to 0.0025 inches and strain in the prepared bars reached 210 micro inches/inch tension, at the slab temperature of 49°F.

Measurements taken 5, 6 and 8 days after construction when the slab temperature dropped to 40°F. indicate that the

pavement was subjected to bending action in the horizontal plane (Plate 6-1). Strain and crack width measurements taken on November 27 when the pavement was 42 days old, tend to verify the "bending action" at the instigated crack.

The curves in Plate 6-7 show that for a given slab temperature the width of the instigated crack decreased in proportion to the distance from the south edge of the pavement. Similarly, strain in the prepared bars decreased linearly from south to north.

Further examination of strain curves in Plate 6-7 reveals that the reinforcing bars closest to the south edge of the pavement started to yield before 42 days measurements were taken. The reinforcing bars closest to the south edge probably started to yield in tension on November 26, or 41 days after construction, when a low of -13°F. was recorded at the Calgary airport.

Considering the previous strain pattern, it is probable that progressive yielding of the reinforcing steel took place with an additional drop in temperature until all the bars spanning the crack yielded in tension.

Examination of strain history at gage points at each side of the crack reveals that loss of bond extended to all gage points west of the crack.

The strain in the prepared bars and the crack width pattern seem to indicate that the horizontal curve tends to straighten out as the pavement contracts due to shrinkage and the temperature drop. With this in mind, it appears that more

reinforcement is required at the intrados lane of the curve.

No other trends can be established at this location because of the very limited data available. The last measurements at this location were taken on November 29, 1958 when the pavement was only 6 weeks old. Subsequent to this date, water entered the terminal box preventing further measurements.

STRAIN – TIME CURVES

SECTION TYPE B6-1 LOCATION VI STATION 304+00

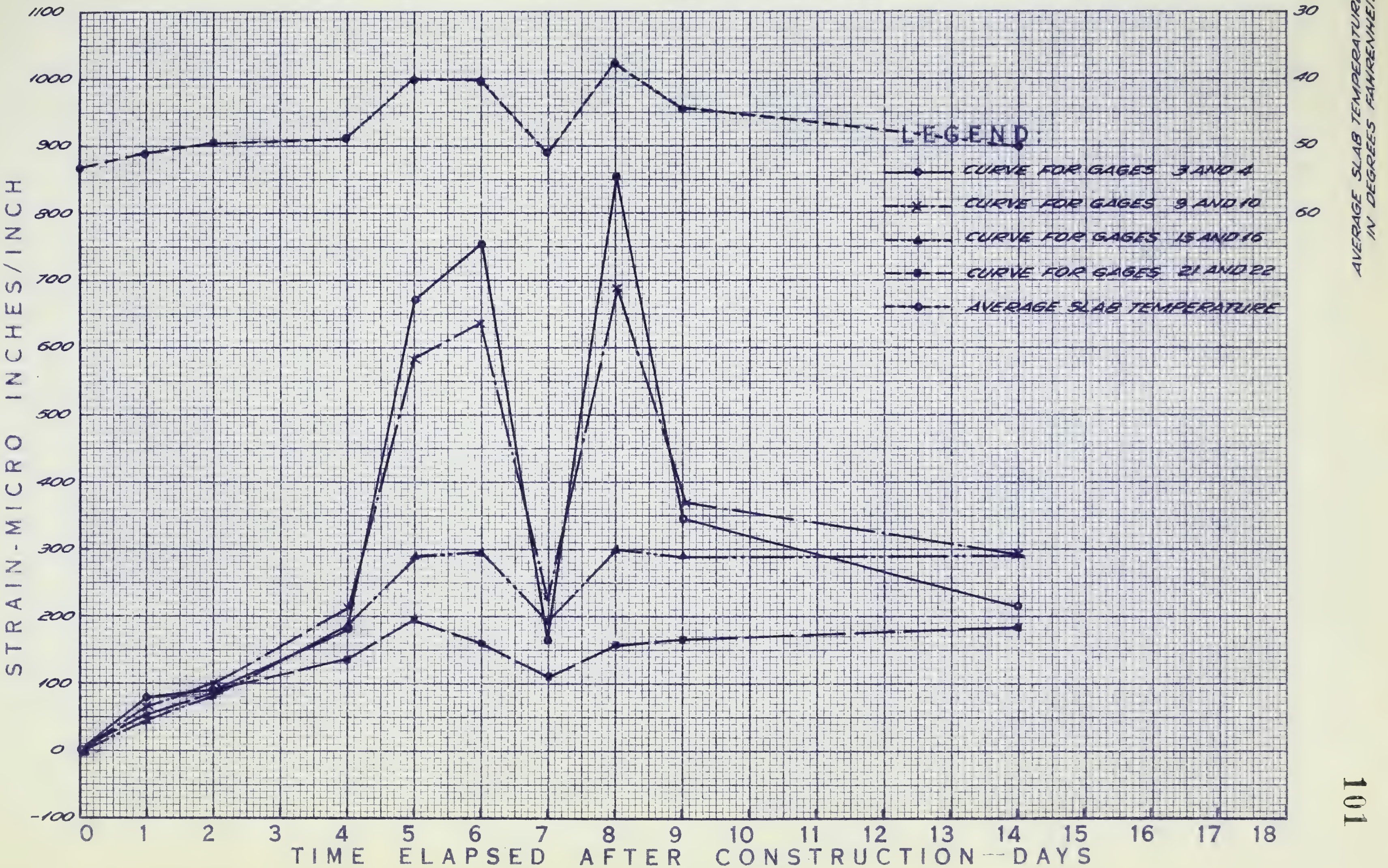


PLATE 6-1

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION VI STATION 304+00

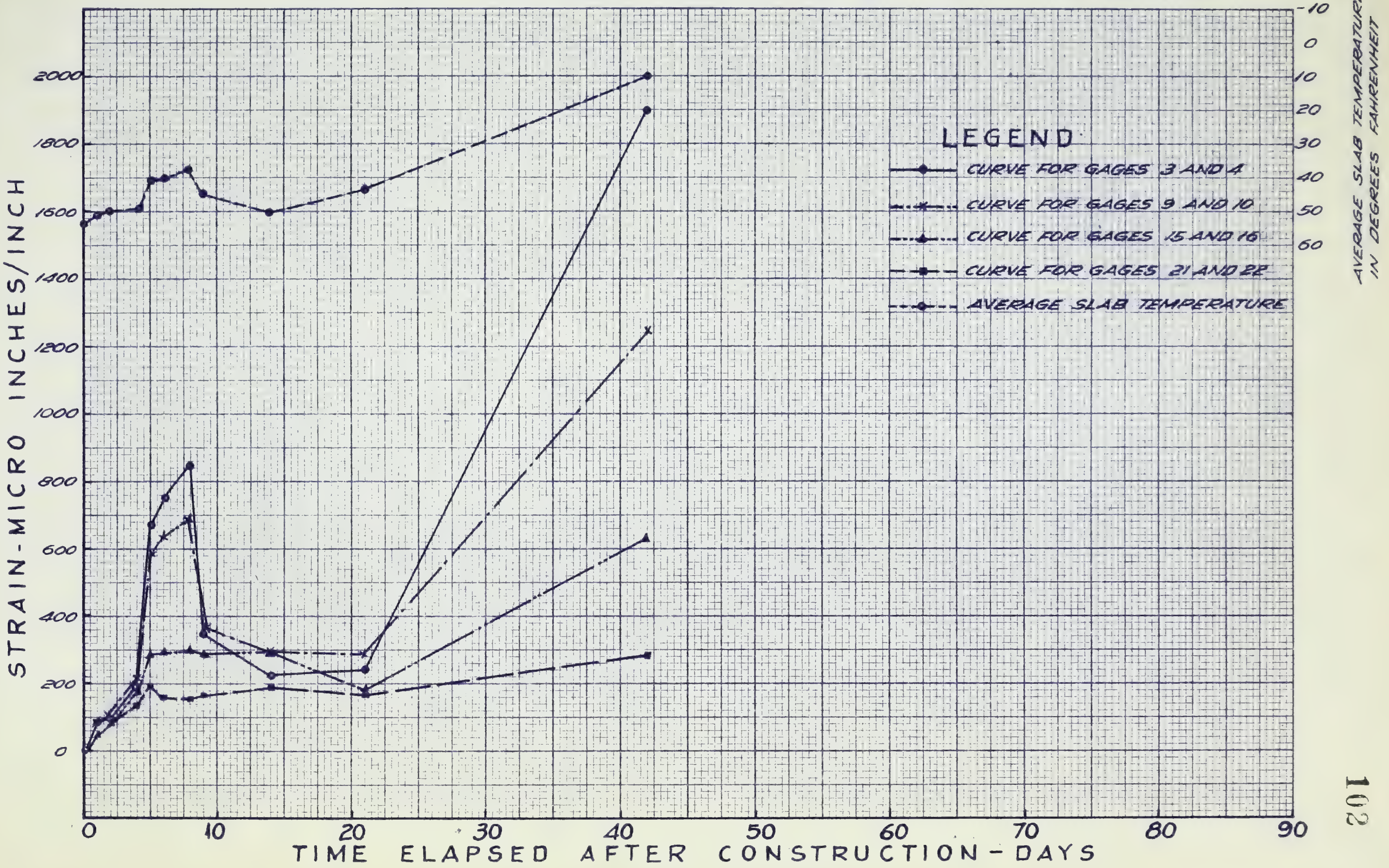


PLATE 6-2

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION VI STATION 304+00

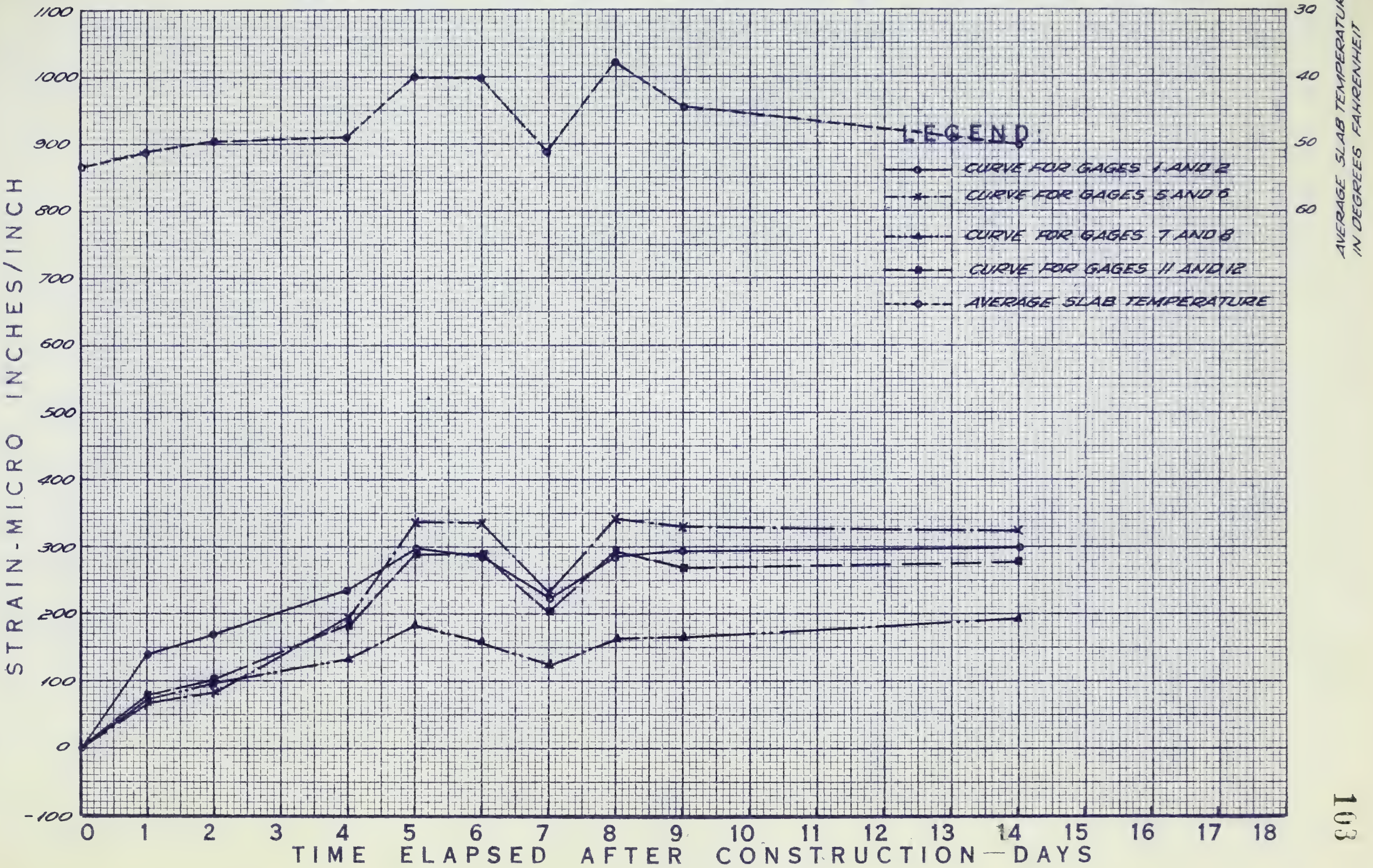


PLATE 6-3

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION VI STATION 304+00

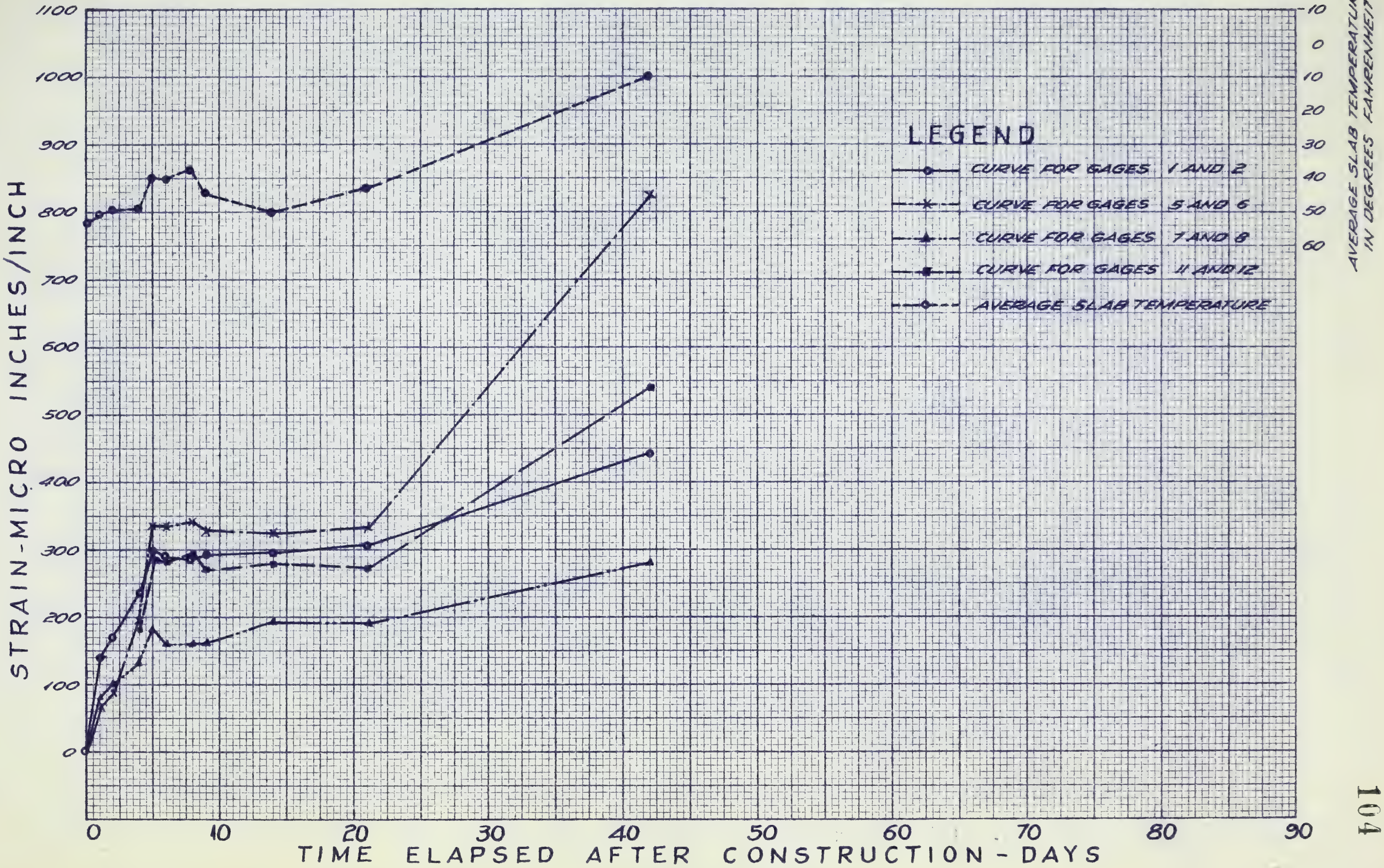


PLATE 6-4

STRAIN—TIME CURVES

SECTION TYPE B6-1 LOCATION VI STATION 304+00

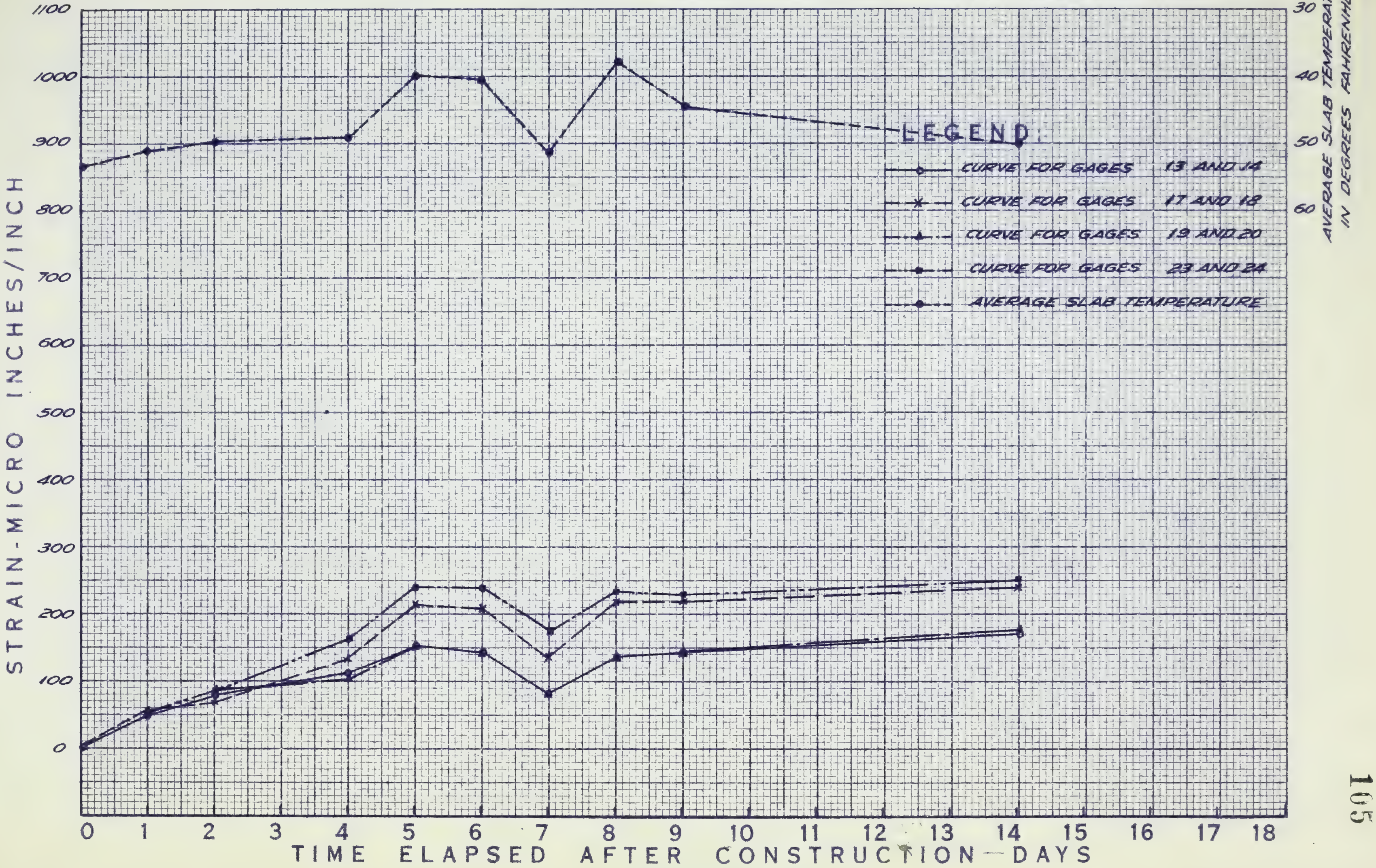


PLATE 6-5

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION VI STATION 304+00

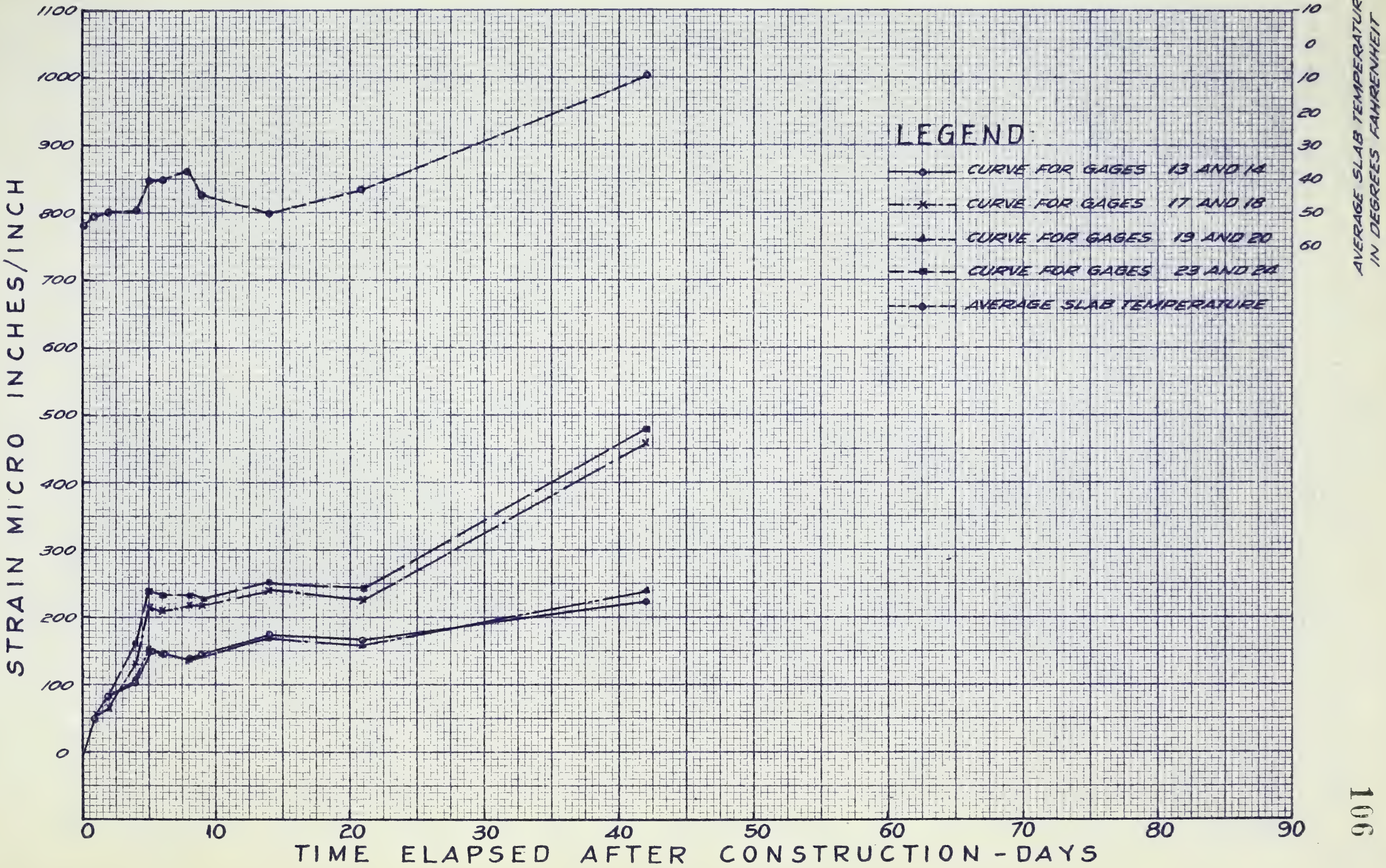


PLATE 6-6

THE INSTIGATED CRACK

SECTION TYPE B6-1 LOCATION VI STATION 304+00

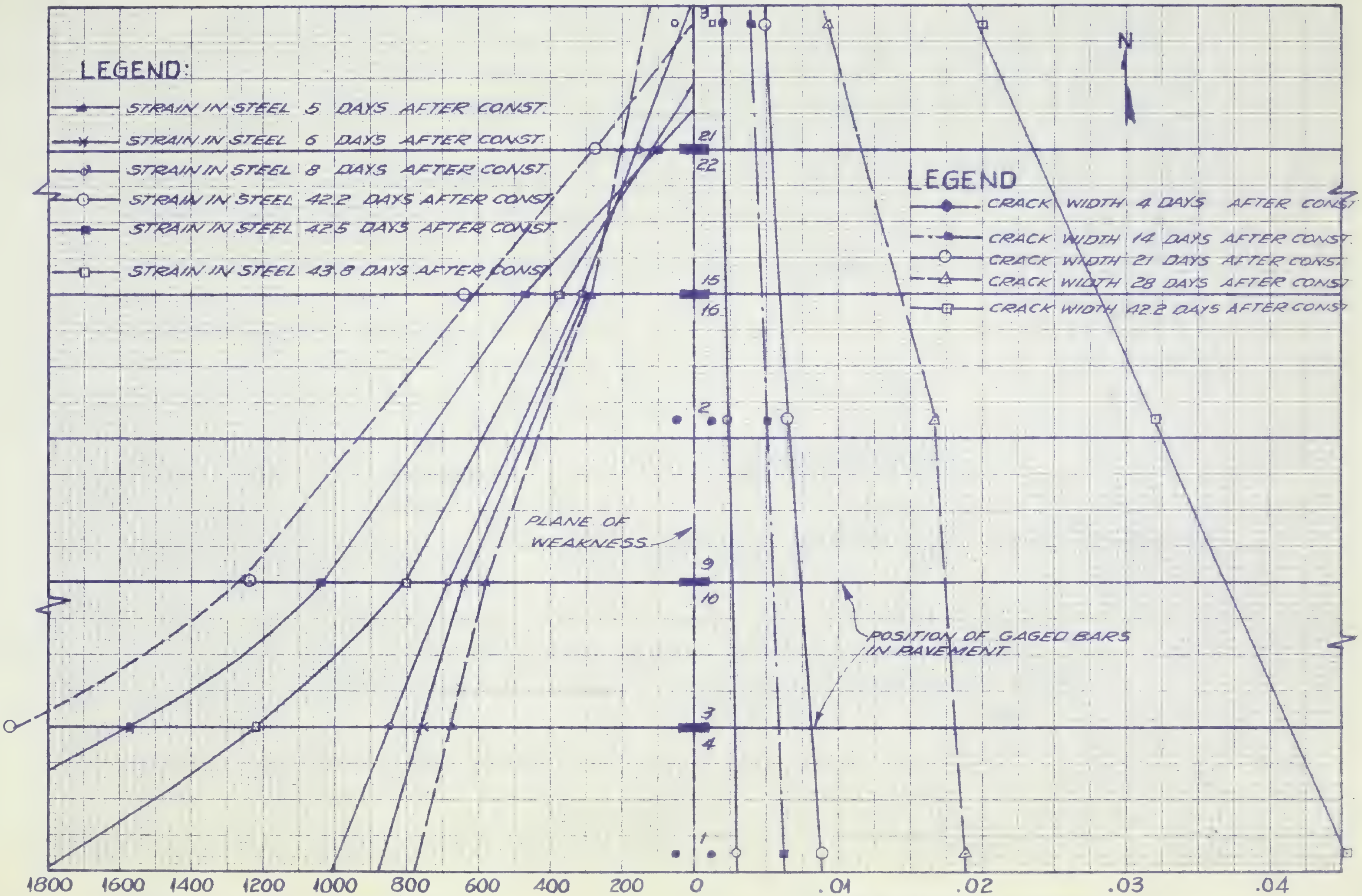


PLATE 6-7

SECTION TYPE B6-1

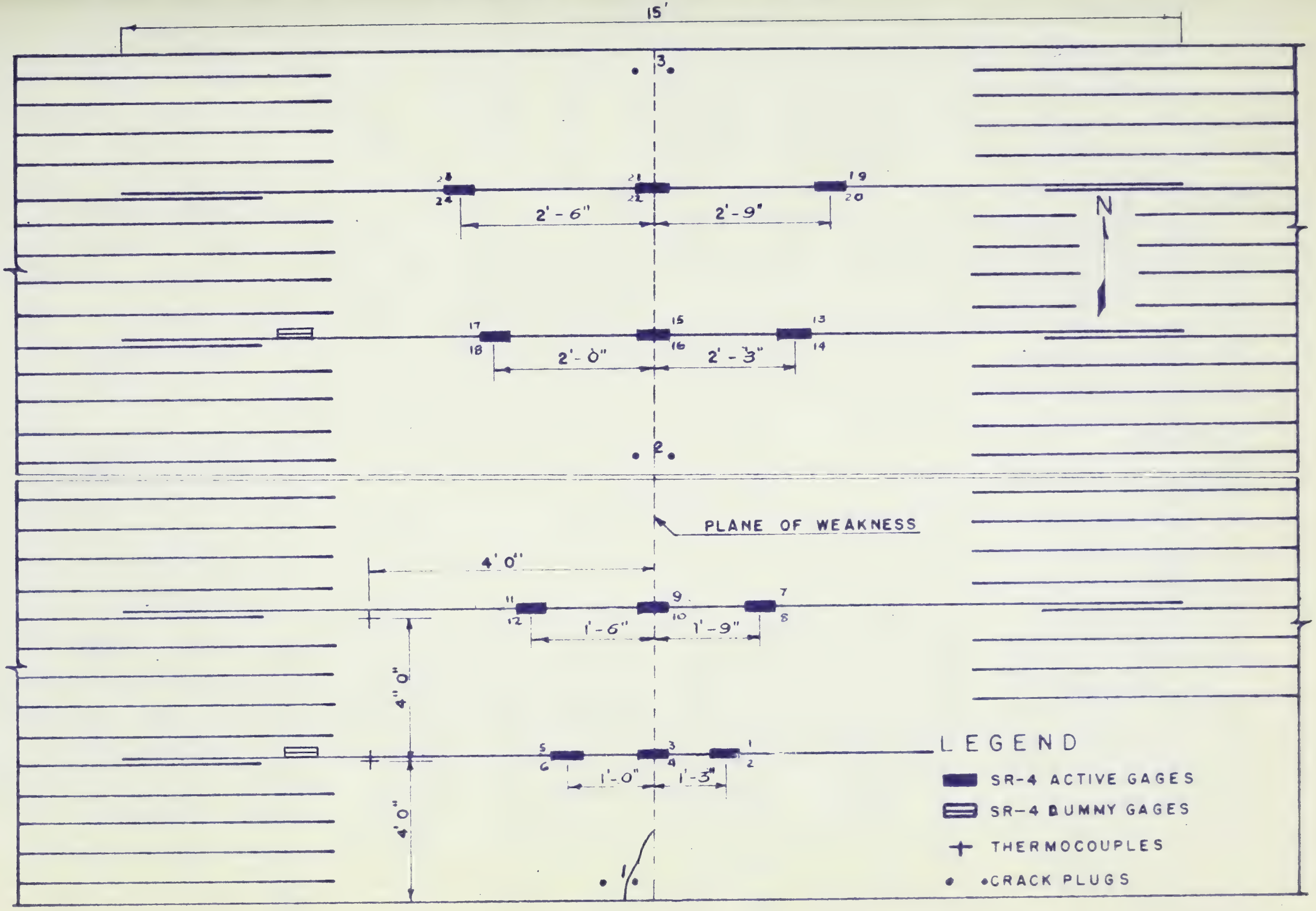


PLATE 6-8

(d) Location VII

The pavement was poured at the test section at 9.00 a.m. on October 16, 1958 when the temperature was 50°F. Initial readings were taken 3 hours after the finishing operation when the average slab temperature was 60°F. The crack was formed at the induced plane of weakness before the pavement was 4 days old.

The strain history in the reinforcing steel at the instigated crack is shown in Plates 7-1 and 7-2. The strain history at the gage points away from the induced plane of weakness is shown in Plates 7-3 to 7-6 inclusive.

The very close relationship between the strain in the reinforcing steel, crack width and slab temperature is shown in Plate 7-2.

Measurements were made when the pavement was 20 days old and the slab temperature was 26°F. The crack opened to 0.026 inches and the gaged bars at the crack were strained to 1160 micro inches/inch in tension.

This was the lowest temperature at which readings were made on the gages before the reinforcing steel spanning the crack yielded in tension.

Some definite trends became apparent at this location after a relatively short period of time. Curve in Plate 7-8 indicates that the width of the crack increased in proportion with the strain in the reinforcing steel. Linear relationship appears to have existed between the slab temperature and the width of the crack and between the slab temperature and the strain in the reinforcing steel at the instigated crack. It

must be pointed out that these relationships are valid when strain in the reinforcing bars remained within the elastic range of the steel. When the strain remained within the elastic range of the reinforcing steel, loss of bond between the concrete and the steel extended to a point 24 bar diameters or 18 inches from the crack. After the reinforcing bars yielded in tension, loss of bond extended beyond the gage point 2'9" from the crack (Plate 7-7).

By extrapolation of the temperature-strain and crack width-strain curves using the yield point strain of the reinforcing steel of 1900 micro inches/inch, it may be shown that the reinforcing bars started to yield at a slab temperature of 6°F. (Plate 7-10), and the width of the crack reached 0.047 inches (Plate 7-8). It may be noticed that this value of the crack width fits very well the temperature-crack width curve (Plate 7-9).

The pavement behaviour at the crack at this location suggest that if a reinforcing steel having a yield point strain of 3100 micro inches/inch had been used, no yielding would have taken place in the reinforcing bars at the crack at a slab temperature of -25°F. and the instigated crack would have opened to 0.074 inches at this extreme low in temperature.

It may be observed in Plate 7-9 that after the reinforcing bars strained past the yield point strain of the steel, the crack at the induced plane of weakness opened to 0.123 inches when the slab temperature was -6°F.

Crack width measurements taken on February 10 and March 7 of 1959 when the slab temperature was -6°F. and 35°F.

respectively, indicate that the width of the crack at the induced plane of weakness was much wider at the south edge of the pavement and decreased linearly from south to north indicating bending in the horizontal plane. See data on Page 261.

CONCLUSIONS

The sub-freezing temperatures had noticeable effects on the pavement behaviour. The tension strains in the prepared bars increased appreciably and the crack at the induced plane of weakness opened wider, resulting in more uniform strains in the reinforcing steel at the crack.

After all the reinforcing bars yielded in tension and the strain equilibrium was established at the crack, bending action became noticeable.

Three out of the four prepared bars yielded in tension before the pavement was 50 days old. Considering the temperature-strain relationship, it is probable that the reinforcing steel started to yield 31 days after construction when a low of -5°F. was recorded for the first time at the Calgary airport.

The lowest temperature of the winter season was recorded at the Calgary airport during the first week of January 1959 when the temperature dropped to -25°F. Measurements made on January 22, 1959 indicate that the reinforcing bars were strained in tension past the range of the "SR-4" bakelite type strain gage.

Loss of bond between the concrete and the reinforcing steel extended to a point about 24 bar diameters from the instigated crack when strain in the reinforcing steel was in

the elastic range. After the reinforcing steel yielded in tension, loss of bond extended beyond a point 44 bar diameters from the crack.

(e) Comparison of Pavement Behaviour at Locations IV to VII in Section Type B6-1

During the first two weeks of the pavement life, similar behaviour was observed at all four locations. Strains of 850 to 900 micro inches/inch tension were measured in the gaged bars at each location during this time. Bending in the horizontal plane became apparent at each location to a varying degree immediately after the shrinkage cracks formed at or in the vicinity of the plane of weakness. Data indicate that bending action was most significant at Locations IV and VI.

The development of shrinkage crack close to the plane of weakness at Locations IV and V occurred very likely before the plane of weakness was induced. It may be observed from the diagrams in Plates 4-5 and 5-5 that the shrinkage crack at both locations formed outside the steel gage points or passed through one of the gage points;as a result the width of the crack at Locations IV and V could not be measured accurately.

It seems that the most significant feature of the early pavement behaviour at Locations IV and VI was bending in the horizontal plane. No other trends seem to be apparent at this time.

Some definite trends become apparent in the pavement at Location VII during its early life. Reasonably good relationship existed between strain in the reinforcing steel, slab temperature and crack width. After the reinforcing steel

spanning the crack yielded in tension, crack width measurements at Location VII tend to indicate bending in the horizontal plane.

In view of the fact that measurements in the test sections in pavement type B6-1 were taken over very short lengths of time, great caution is suggested in drawing any conclusions as to the future pavement behaviour in this section.

Considering the strain history in the reinforcing steel, crack width, spacing of cracks and loss of bond between concrete and the steel, it seems reasonable to assume that the worst conditions were encountered at Location VII, and any comparisons that are made between different section types should be made with this location in mind.

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION VII STATION 303+00

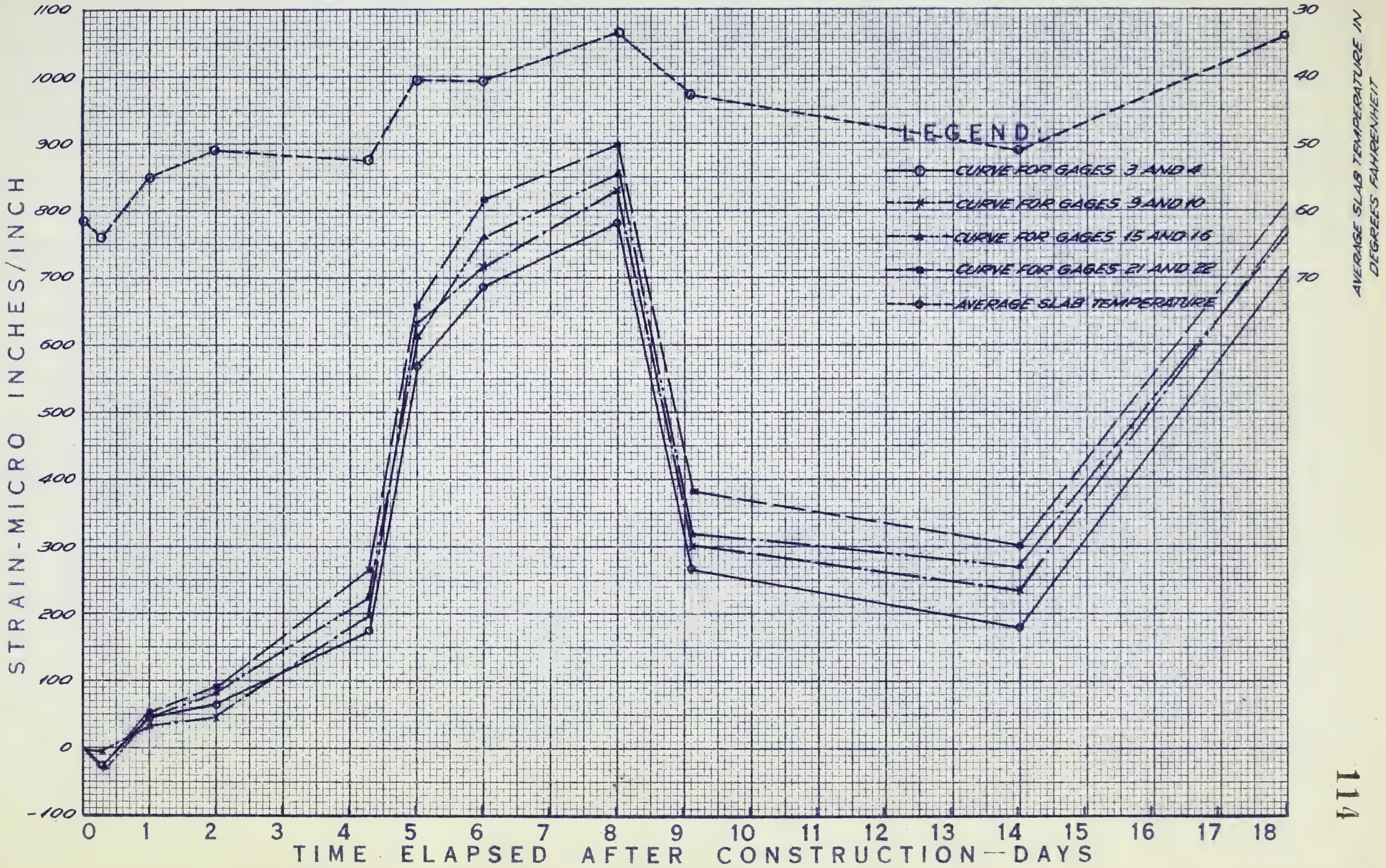


PLATE 7-1

STRAIN TIME CURVES

SECTION TYPE B6-1 LOCATION VIII STATION 303+00

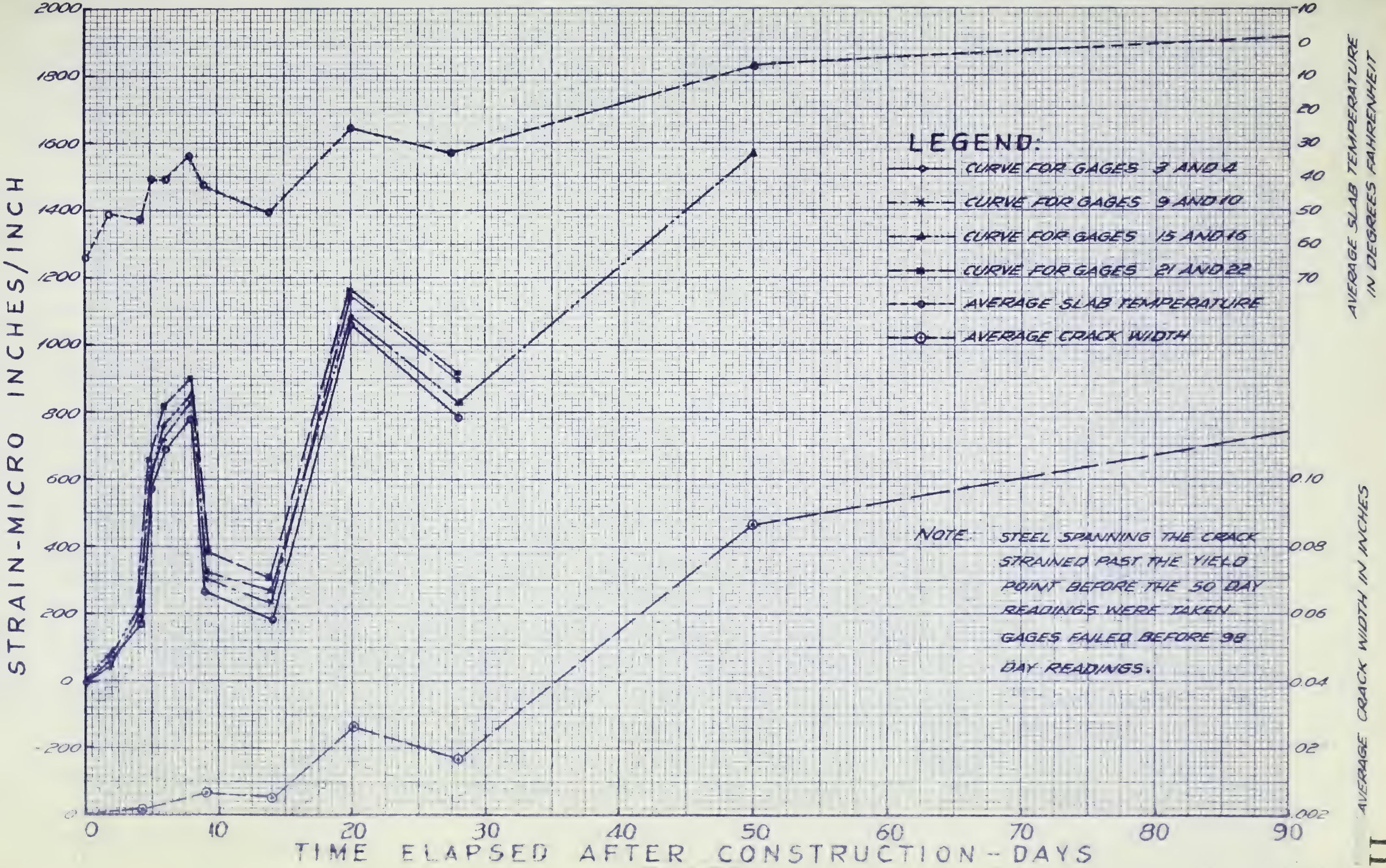


PLATE 7-2

STRAIN-TIME CURVES

SECTION TYPE B6-1 LOCATION VII STATION 303+00

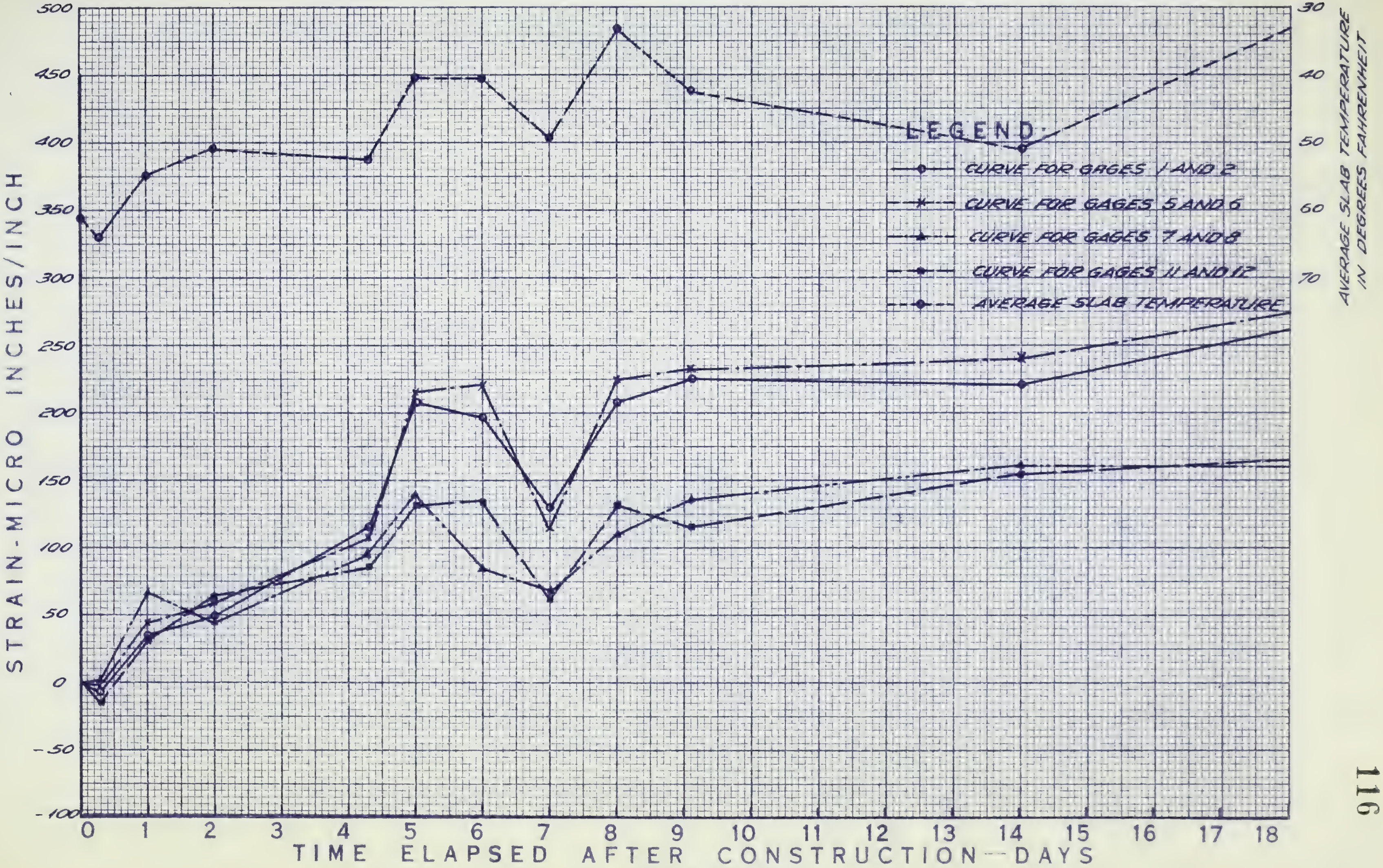


PLATE 7-3

STRAIN TIME CURVES

SECTION TYPE B6-1 LOCATION VII STATION 303+00

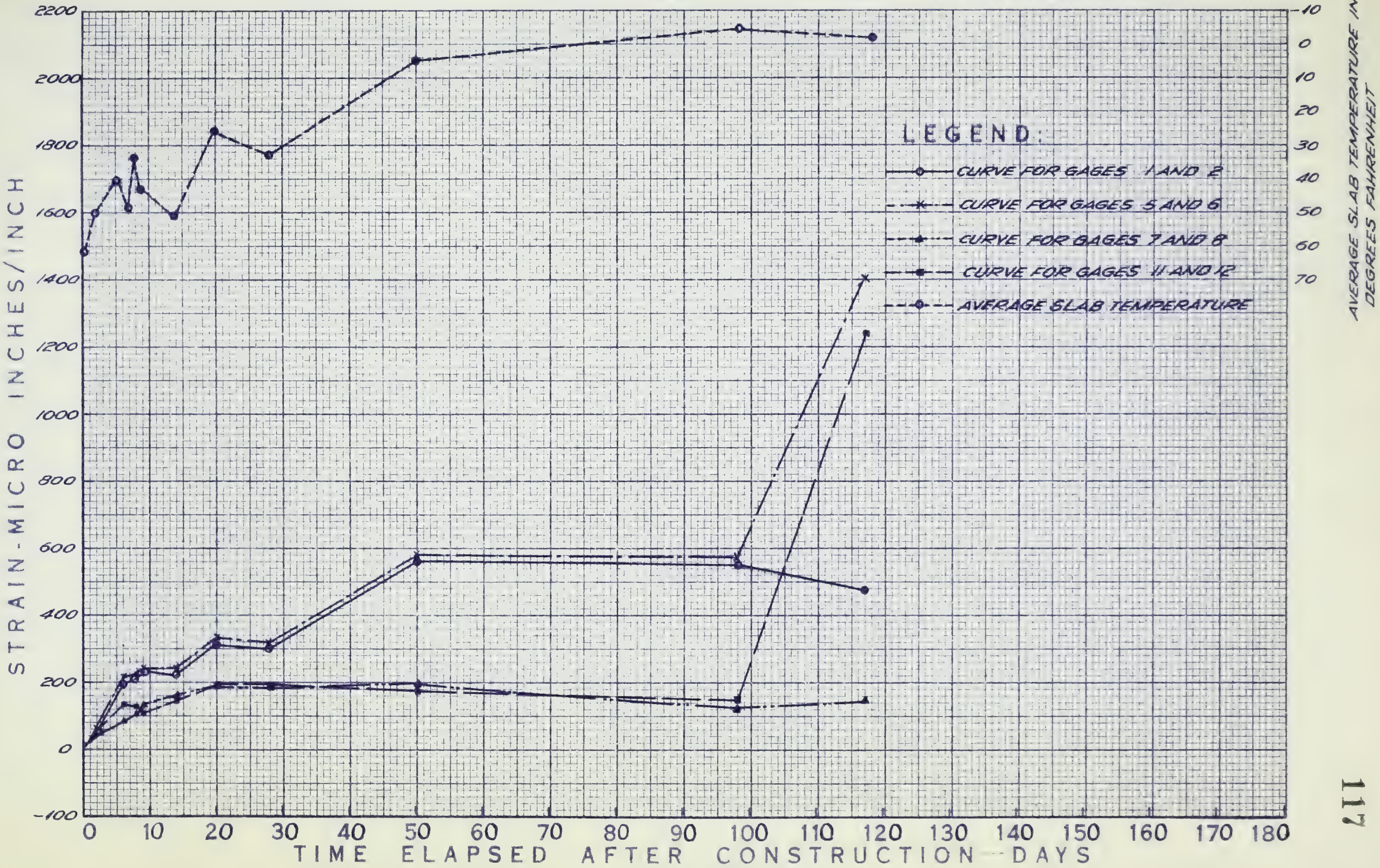


PLATE 7-4

STRAIN—TIME CURVES

SECTION TYPE B6-1 LOCATION VII STATION 303+00

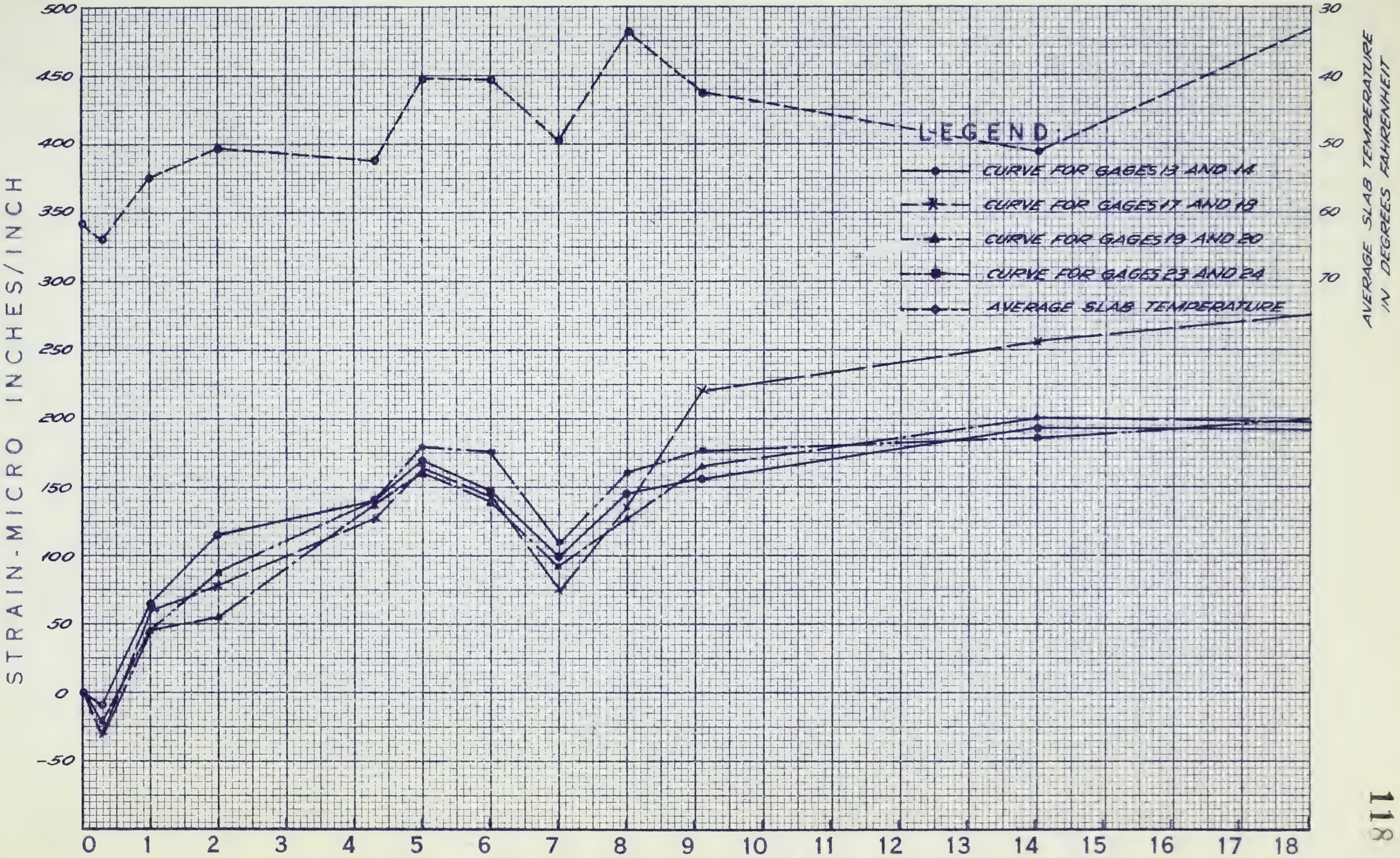


PLATE 7-5

STRAIN—TIME CURVES

SECTION TYPE B6-1 LOCATION VII STATION 303+00

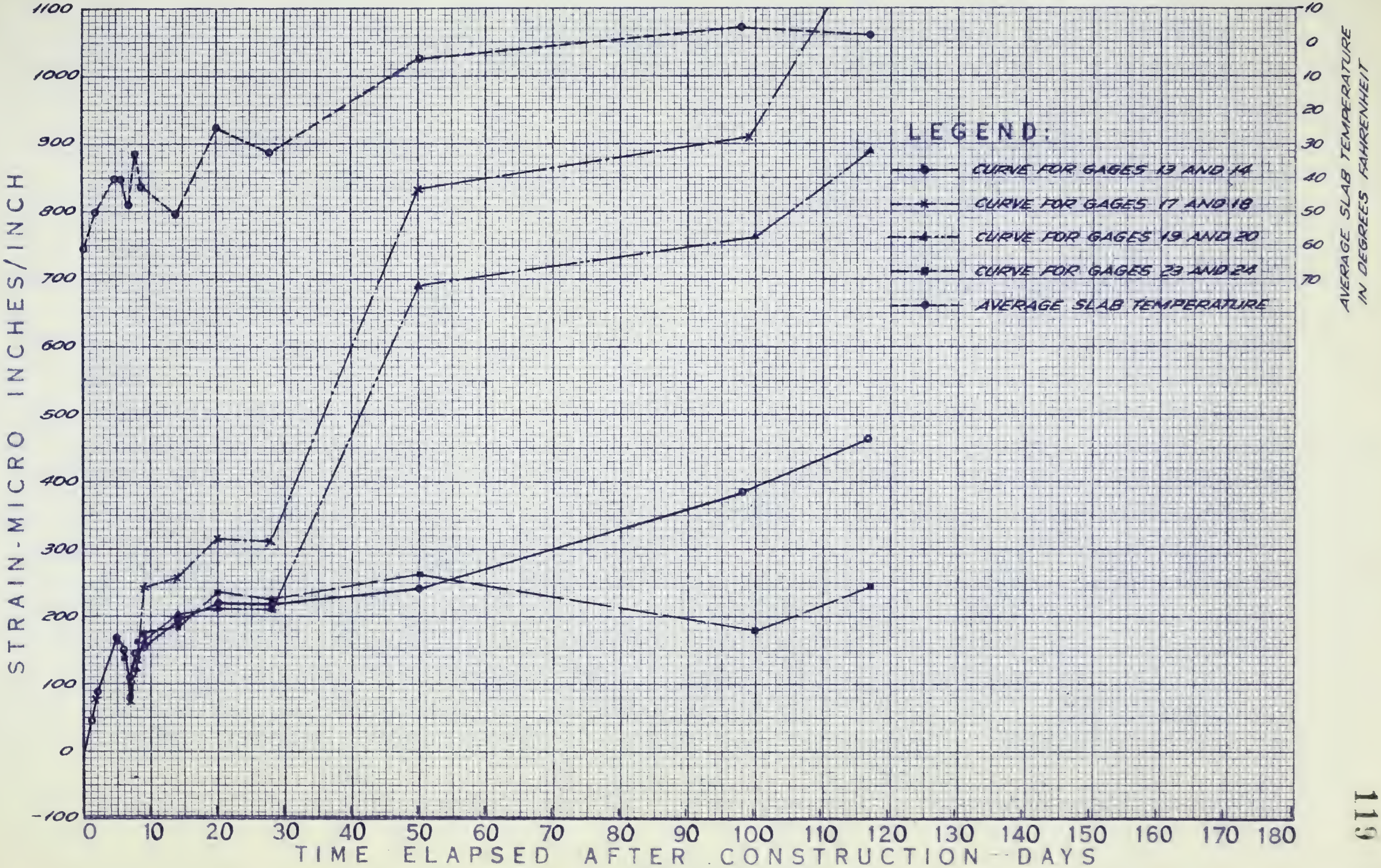


PLATE 7-6

STRAIN TRANSFER DISTRIBUTION CURVES

SECTION TYPE B6-1 LOCATION VIII STATION 303+00

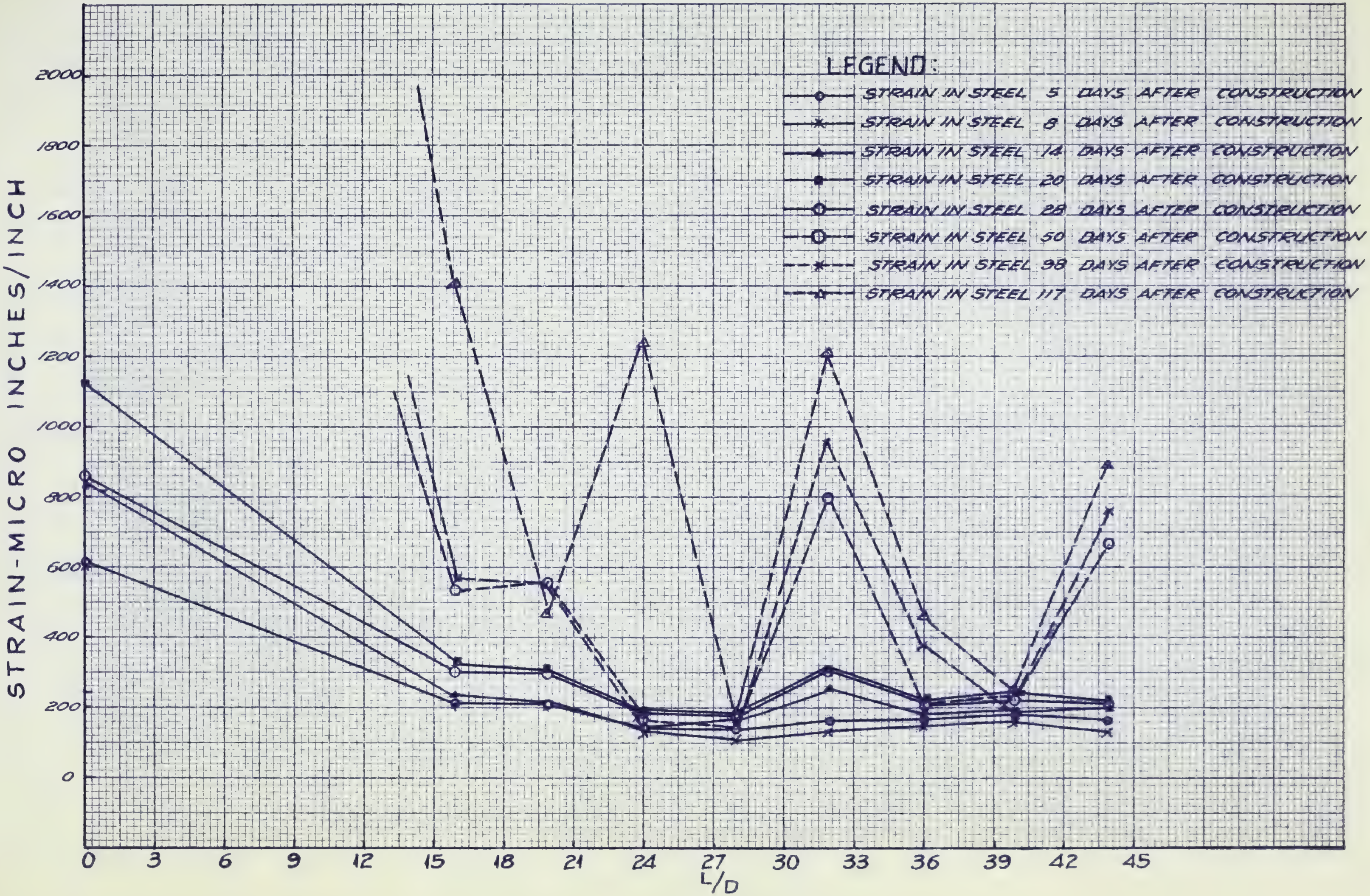


PLATE 7-7

STEEL STRAIN - CRACK WIDTH CURVE

SECTION TYPE B6-1 LOCATION VIII STATION 303+00

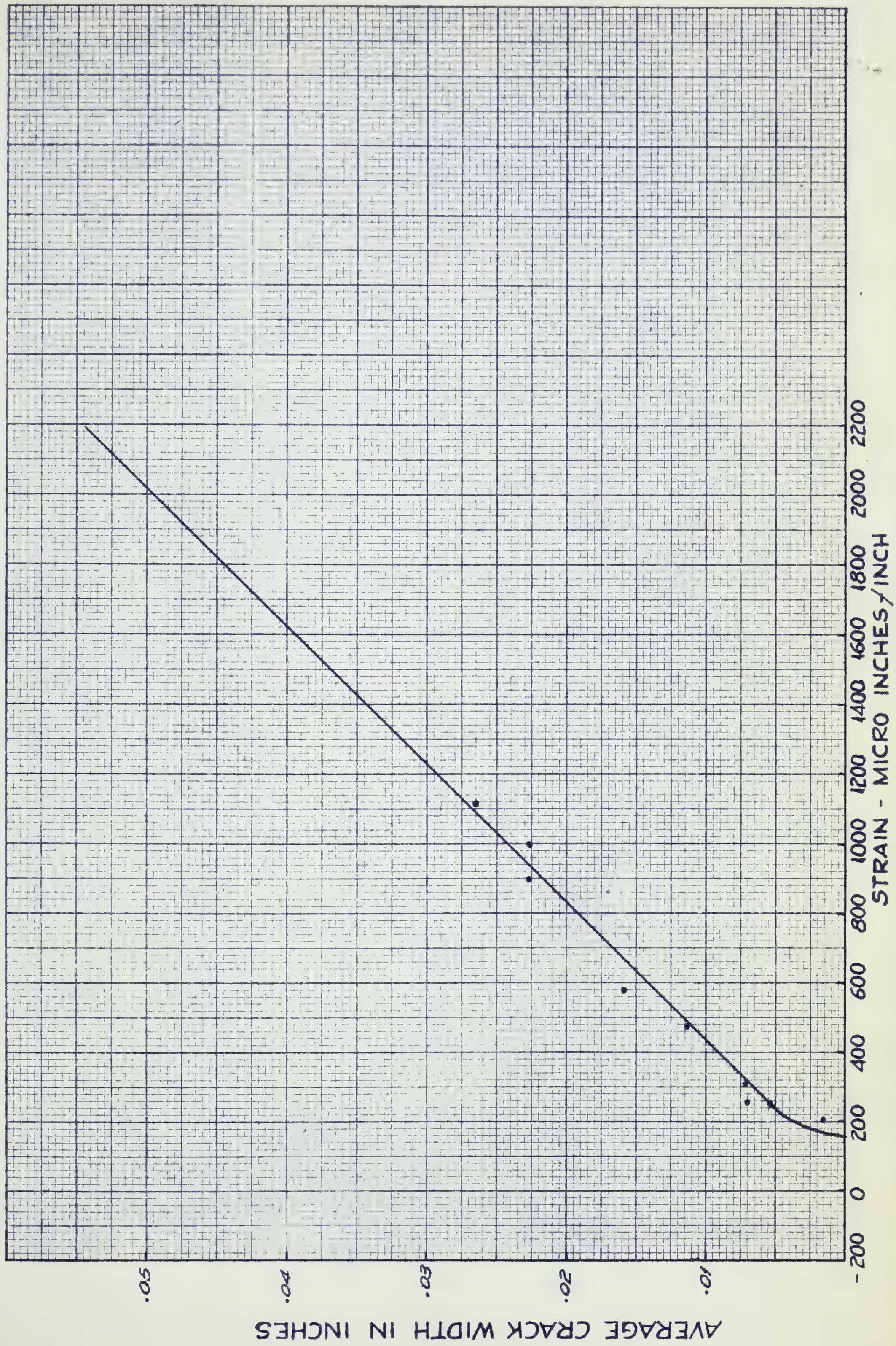


PLATE 7-8

SLAB TEMPERATURE - CRACK WIDTH CURVE

SECTION TYPE B6-1 LOCATION VII STATION 303+00

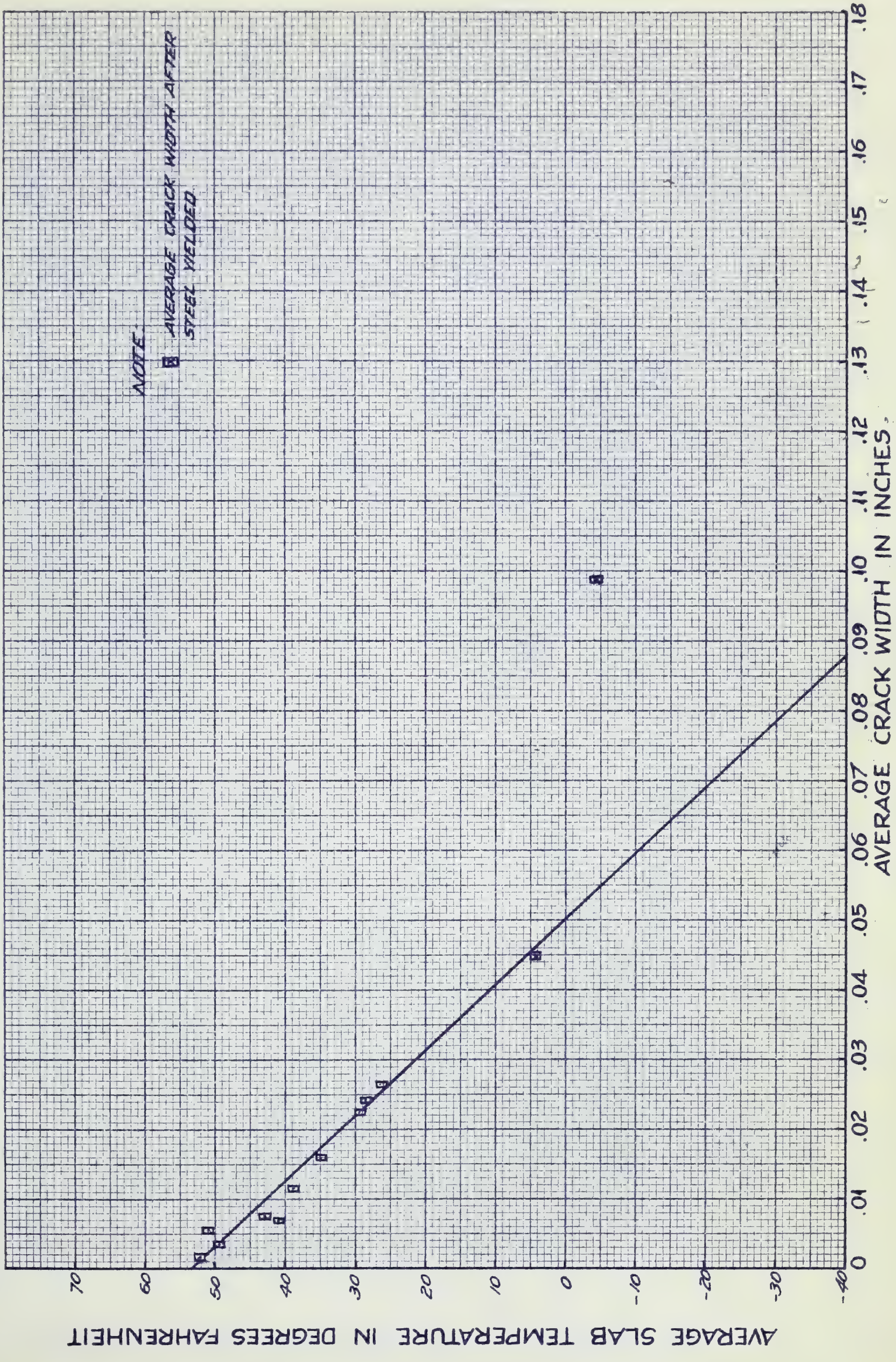


PLATE 7-9

TEMPERATURE - STRAIN CURVE

SECTION TYPE B6-1 LOCATION VIII STATION 303+00

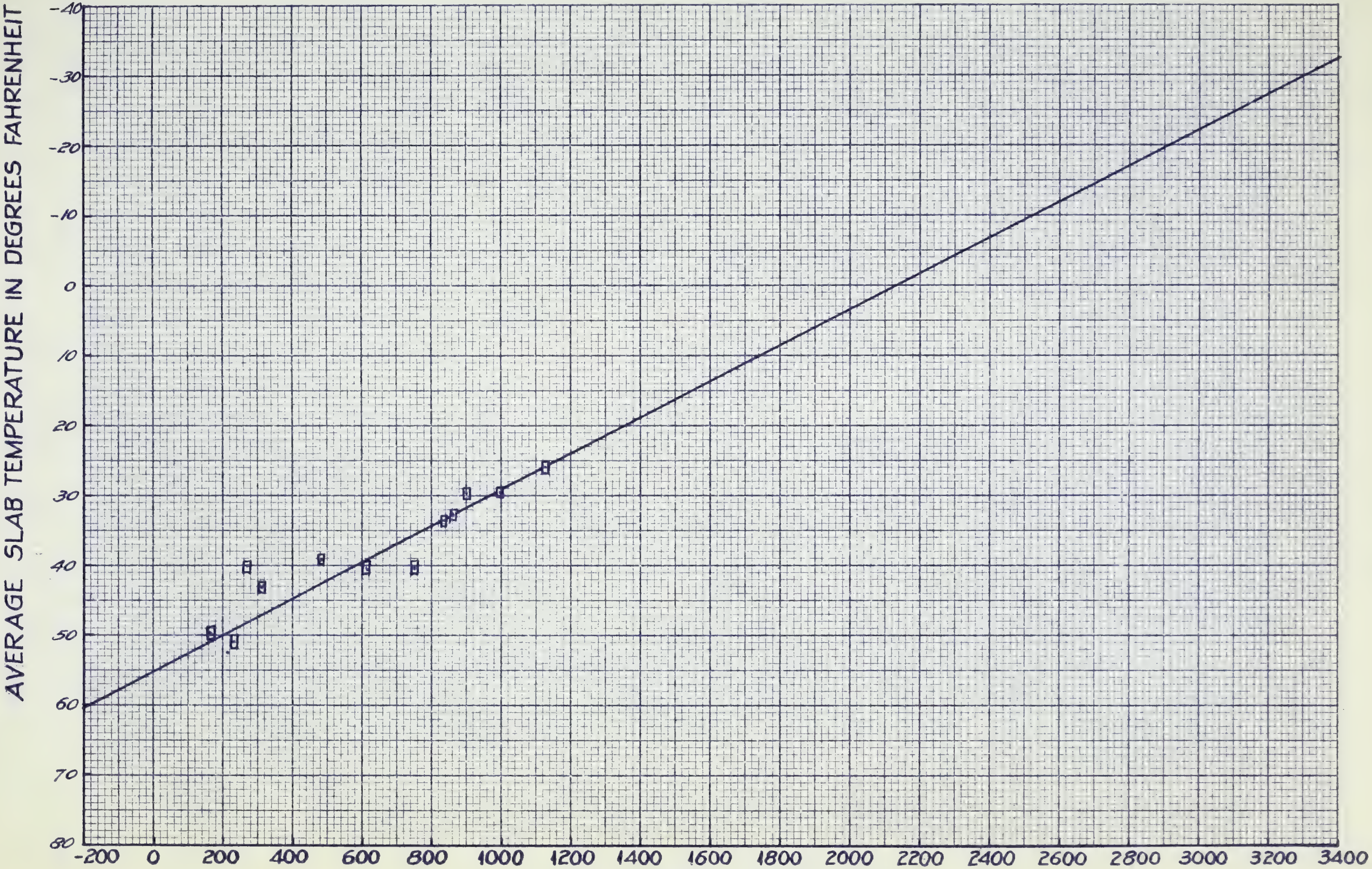


PLATE 7-10

SECTION TYPE B6-1

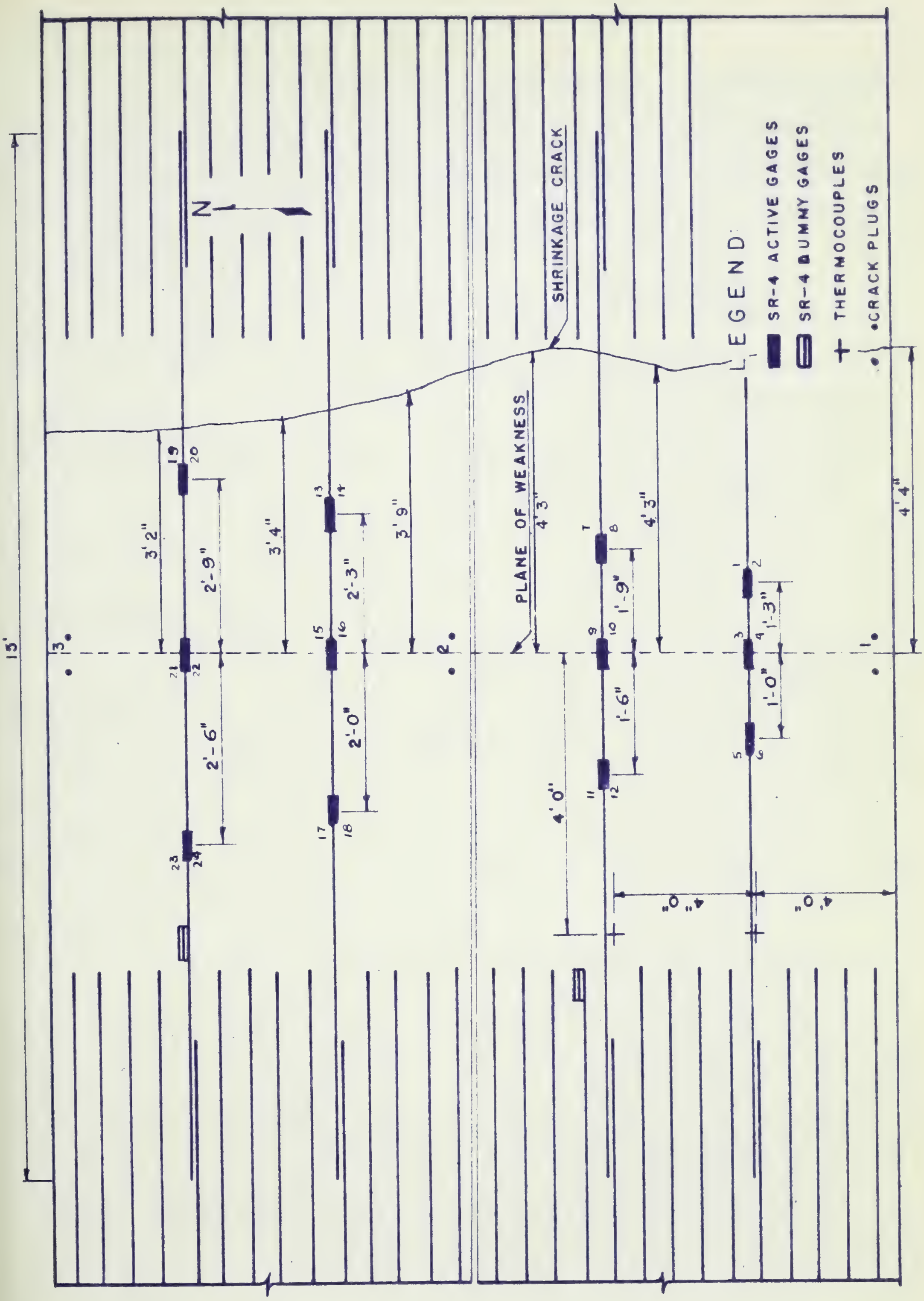


PLATE 7-11

4. Section Type B6-2

The continuously reinforced concrete pavement, Type B6-2, 2204.5 feet in length, consists of a six inch slab reinforced with No. 6 intermediate grade deformed bars comprising a 0.815% cross-section area of the pavement. (For full details see Plate 4.)

Prepared bars were placed at two cross-sections in this test strip. The test sections located at stations 294+00 and 289+50 are referred to from here on as Location VIII and Location IX respectively. The test section at Location VIII was constructed on a 25 foot "fill" and at Location IX in a 2 foot "cut".

(a) Location VIII

The pavement was poured at the test section at 7 a.m. on October 20, 1958 when the air temperature was at 30°F. The first set of readings was taken two hours after the finishing operation when the air temperature was at 32.5°F. and the slab temperature was at 47°F. The crack developed at the induced plane of weakness when the pavement was between three and five days old.

The strain history in the reinforcing steel at the instigated crack is shown in Plates 8-1 and 8-2. Curves in Plates 8-3 and 8-6 represent the strain record in the reinforcing bars at the gage points on each side of the plane of weakness.

The diagram in Plate 8-12 shows the position of the strain gages, steel gage points, temperature gages and the location of the two cracks which developed before the pavement

was 46 days old. A crack survey taken on March 7, 1959, when the pavement was 138 days old, indicates that an additional crack developed two feet east of the plane of weakness.

The very close relationship between the strain in the reinforcing steel, crack width and slab temperature is shown in Plates 8-1, 8-2 and 8-8.

Measurements taken during the first two weeks after construction when the slab temperature varied between 40 and 50°F. indicate that the reinforcing steel at the crack was strained to 600 micro inches/inch in tension and the crack opened to 0.01 inches.

Measurements taken 16 days after construction, when the slab temperature was 18°F, show that the strain in the reinforcing bars reached 1,200 micro inches/inch in tension and the width of the crack increased to 0.228 inches. This was the lowest temperature at which the readings were made on the gages before the reinforcing steel at the crack yielded in tension.

Measurements made on November 27 and 28, 1958 when the pavement was 38 to 39 days old and the slab temperature varied between zero and 27°F., indicate that the prepared bars at the crack yielded far beyond the yield point strain of the steel. Considering the previous strain history, combined with a knowledge of the reinforcing steel characteristics, it is probable that the reinforcing bars yielded in tension 37 days after construction when a low of -13°F. was recorded at the Calgary airport for the first time.

The strain gages at the instigated crack failed before the 94 day measurements were taken. Temperature records at the Calgary airport indicate that a low of -25°F. was recorded during the first week of January 1959. It is believed that the reinforcing steel at the crack strained past the range of the "SR-4" bakelite gages at this extreme low in temperature, resulting in the eventual failure of these gages.

When the strain in the reinforcing bars spanning the crack remained in the elastic range, loss of bond between the concrete and the steel extended to a point 16 bar diameters or 12 inches from the crack. After the reinforcing bars yielded beyond the range of "SR-4" strain gages, the loss of bond extended to a point 32 bar diameters or 24 inches from the crack.

By extrapolation of temperature-strain and crack width-strain curves, it may be shown that the prepared bars started to yield at a slab temperature of -5°F. and the instigated crack opened to 0.039 inches (Plates 8-11 and 8-9). It is also apparent from these curves that if a reinforcing steel having a yield point strain of about 2,700 micro inches/inch had been used, no yielding would have occurred at the cracks. However, more new cracks would have probably developed and the cracks would not have opened to such objectionable widths.

It may be observed in Plate 8-10 that the width of the crack opened to 0.07 inches when the slab temperature was -5°F. after the reinforcing steel spanning the crack yielded

in tension. However, it is believed that an additional crack developed two feet east of the plane of weakness before this measurement was taken.

Conclusions

The strain history at the gage points on each side of the induced plane of weakness seems to indicate that during the first few days of the pavement life when the concrete was weak relative movement between the concrete and the steel took place due to constant temperature cycling. This type of action prevented the formation of the adhesive bond between the concrete and the steel resulting in purely mechanical bond development at the extreme limits of the differential movement between the concrete and the deformations on the reinforcing bar.

The formation of an additional crack in the test section when the slab was subjected to extremely low temperatures prevented the instigated crack from opening much wider.

STRAIN TIME CURVES

SECTION TYPE B6-2 LOCATION VIII STATION 294+00

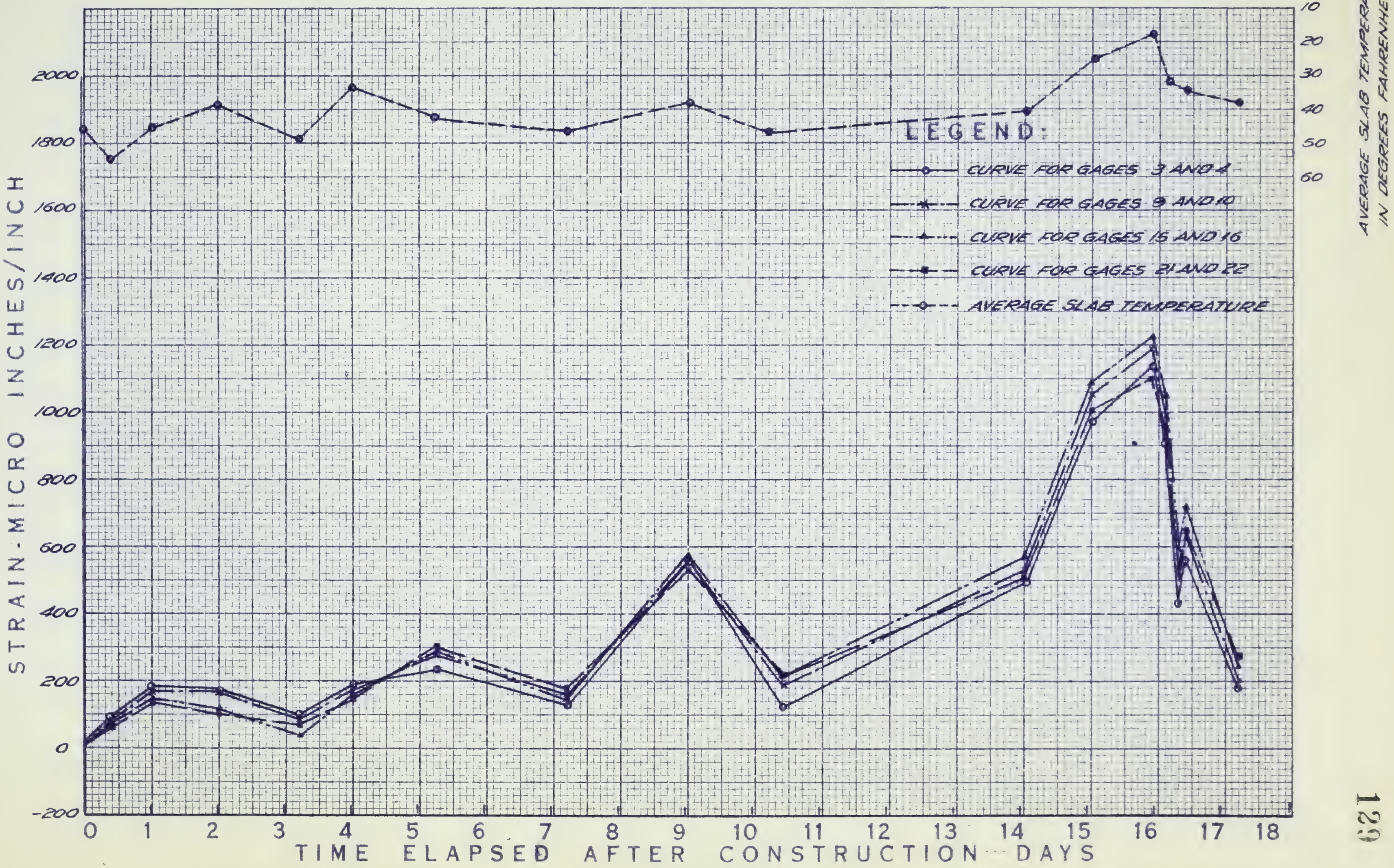


PLATE 8-1

STRAIN-TIME CURVES

SECTION TYPE B6-2 LOCATION VIII STATION 294+00

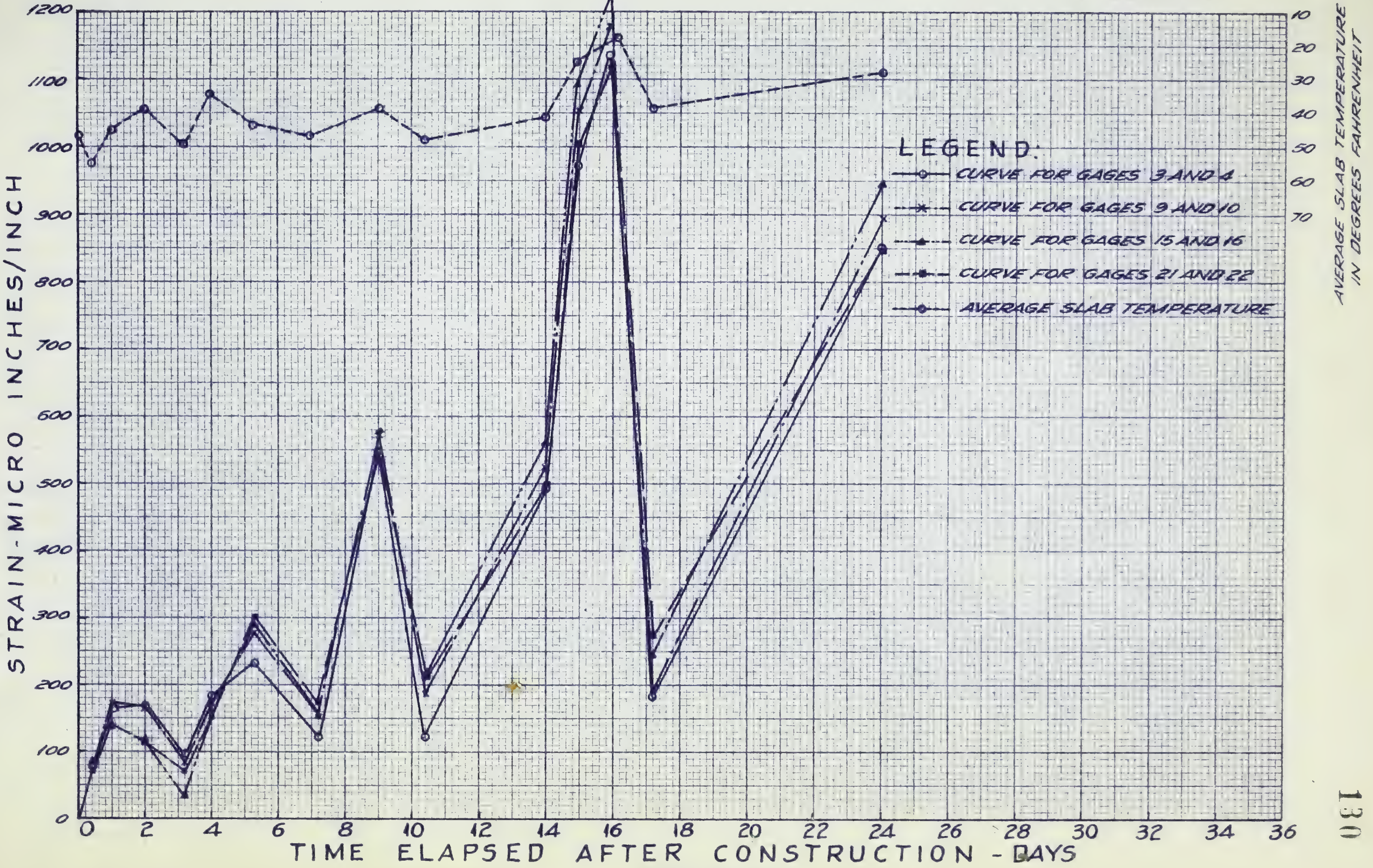


PLATE 8-2

STRAIN—TIME CURVES

SECTION TYPE B6-2 LOCATION VIII STATION 294+00

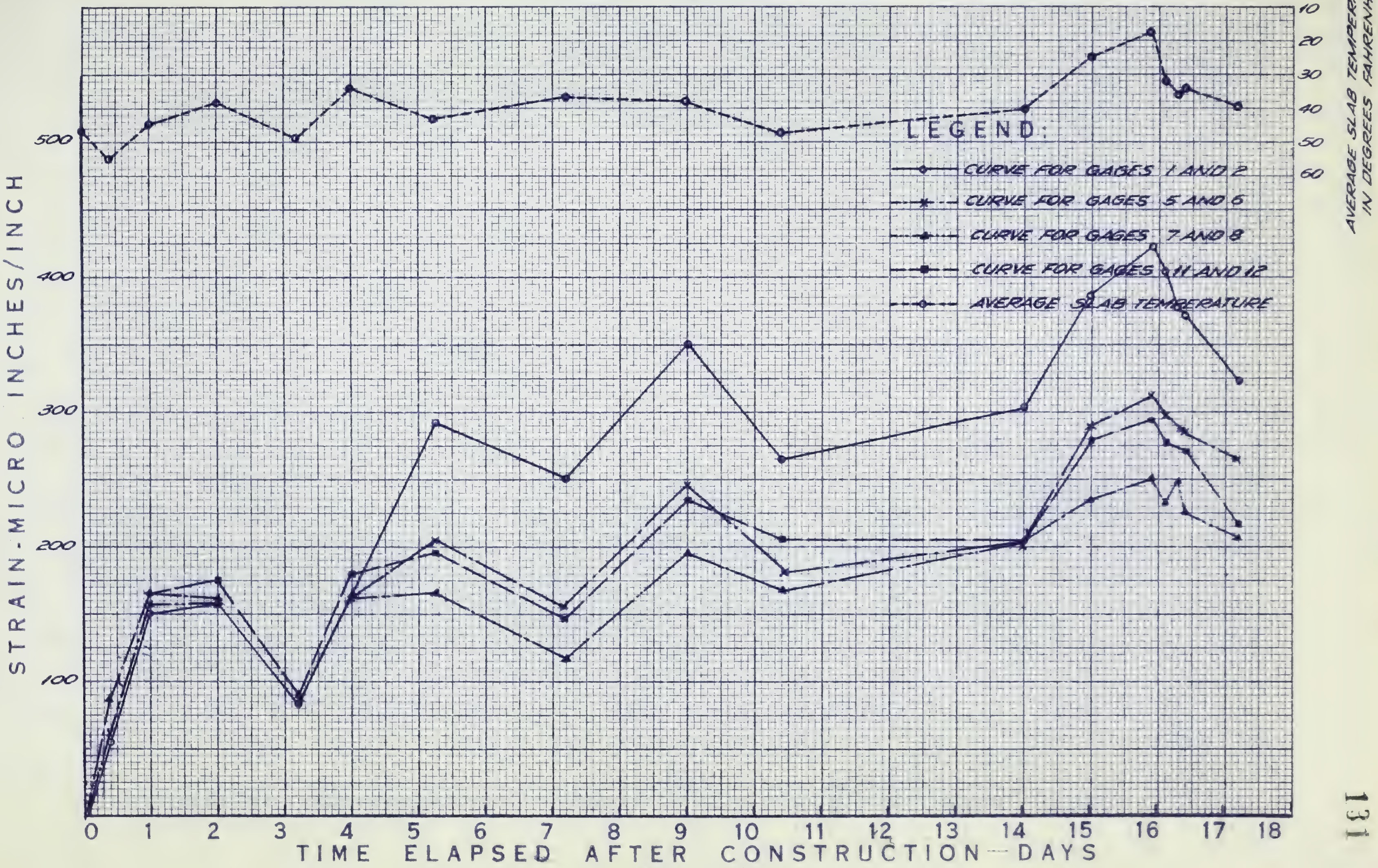


PLATE 8-3

STRAIN—TIME CURVES

SECTION TYPE B6-2 LOCATION VIII STATION 294+00

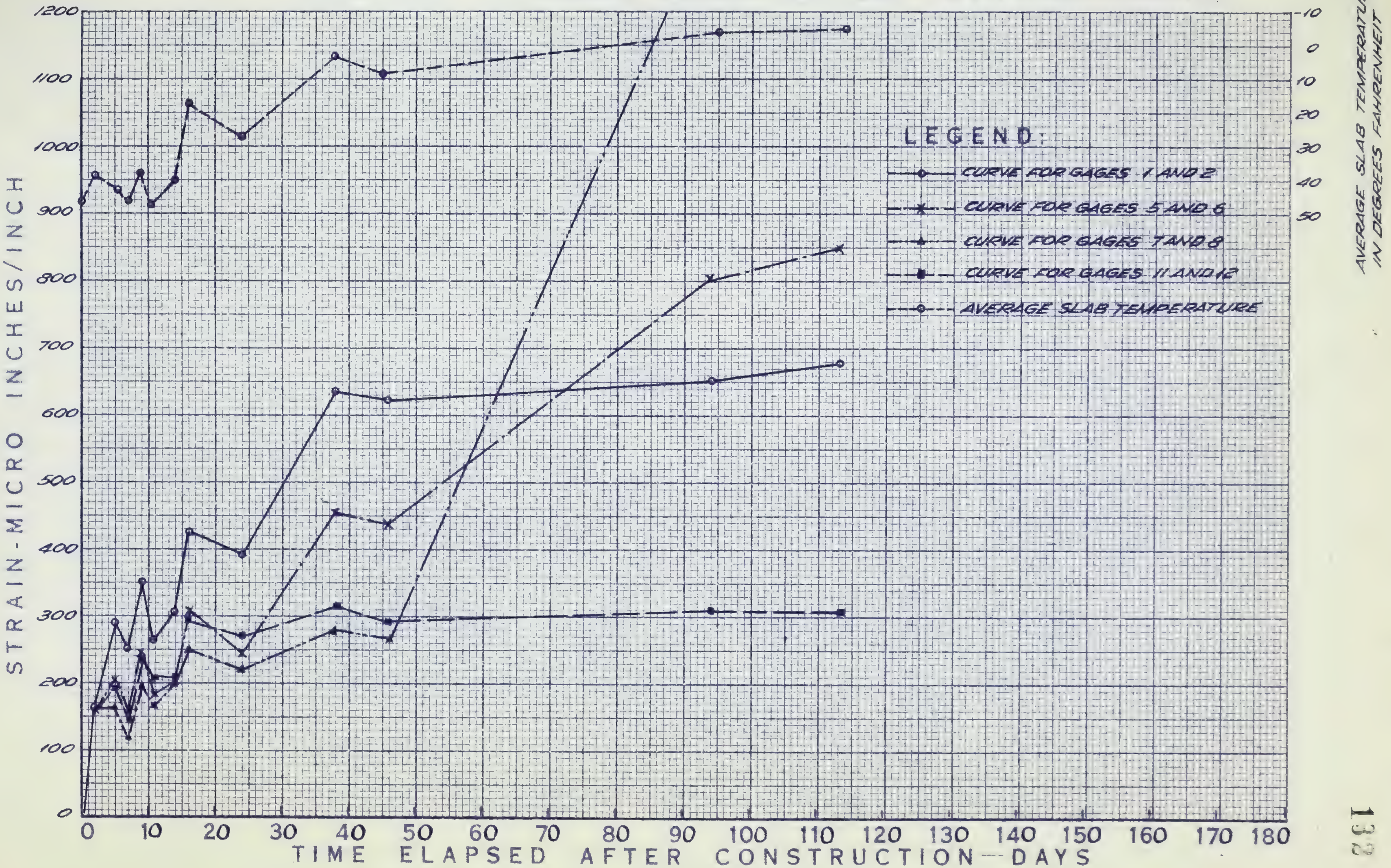


PLATE 8-4

STRAIN-TIME CURVES

SECTION TYPE *B6-2* LOCATION *VIII* STATION *294+00*

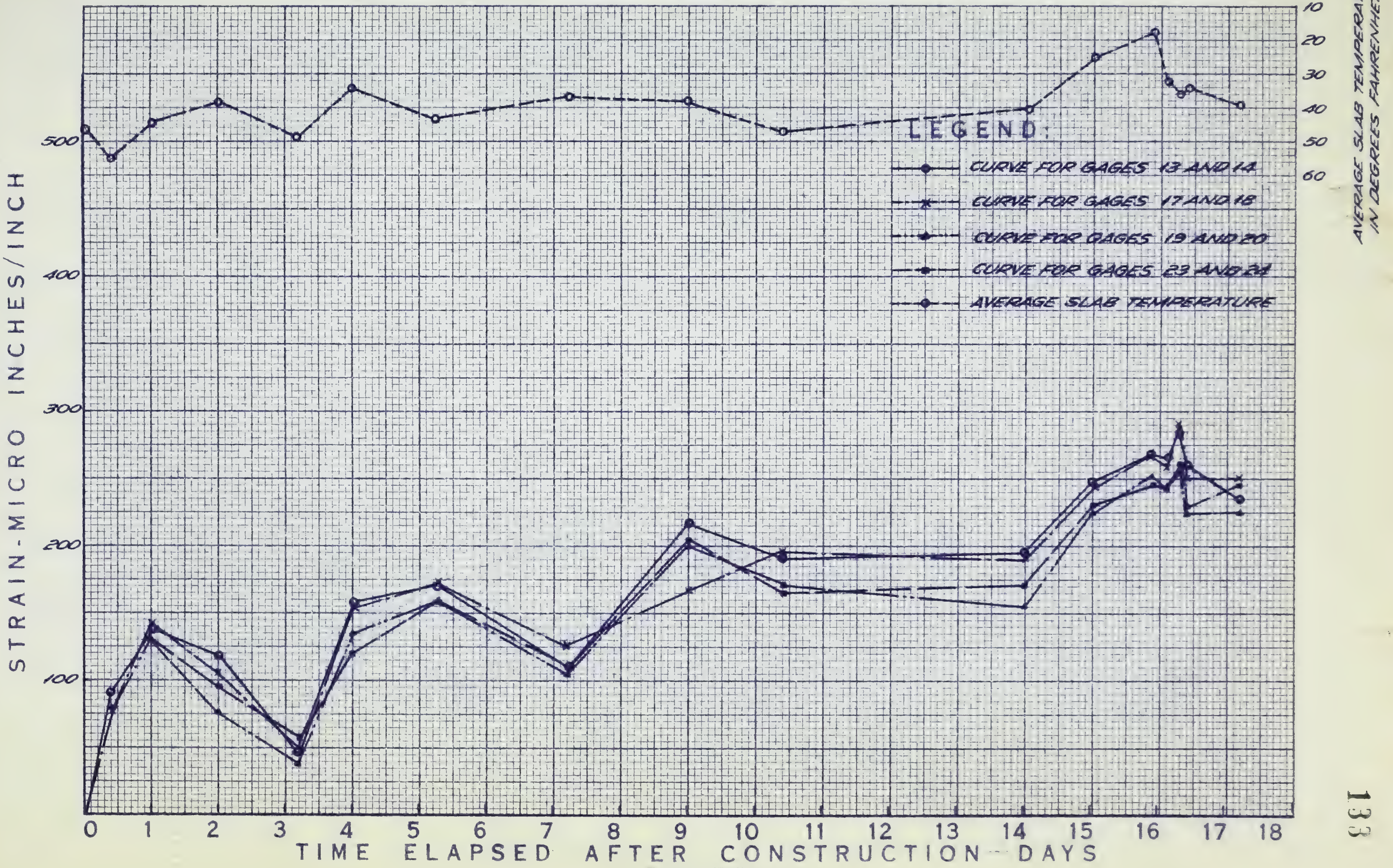


PLATE *8-5*

STRAIN-TIME CURVES

SECTION TYPE B6-2 LOCATION VIII STATION 294+00

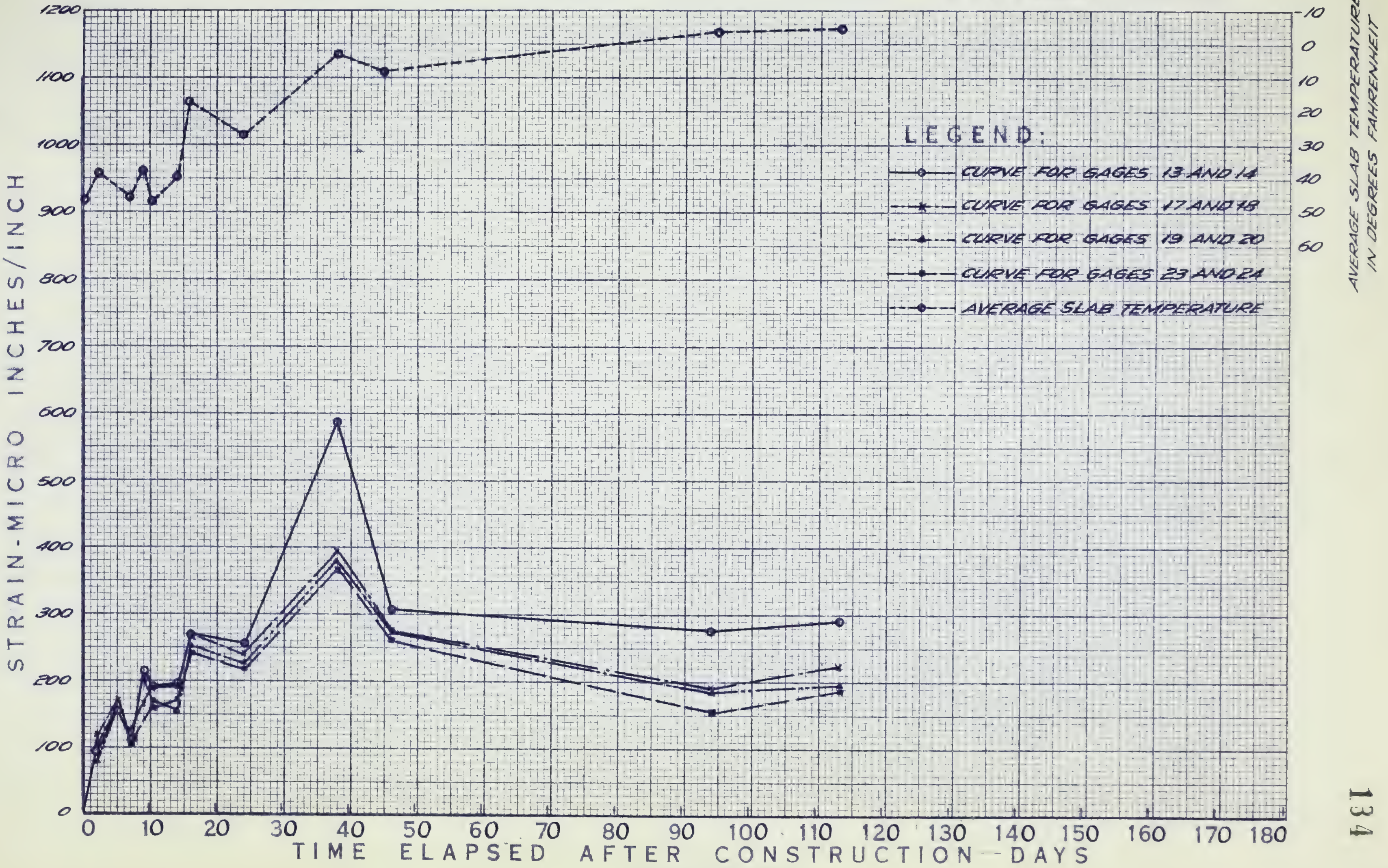


PLATE 8-6

STRAIN TRANSFER DISTRIBUTION CURVES

SECTION TYPE B6-2 LOCATION VIII STATION 294+00

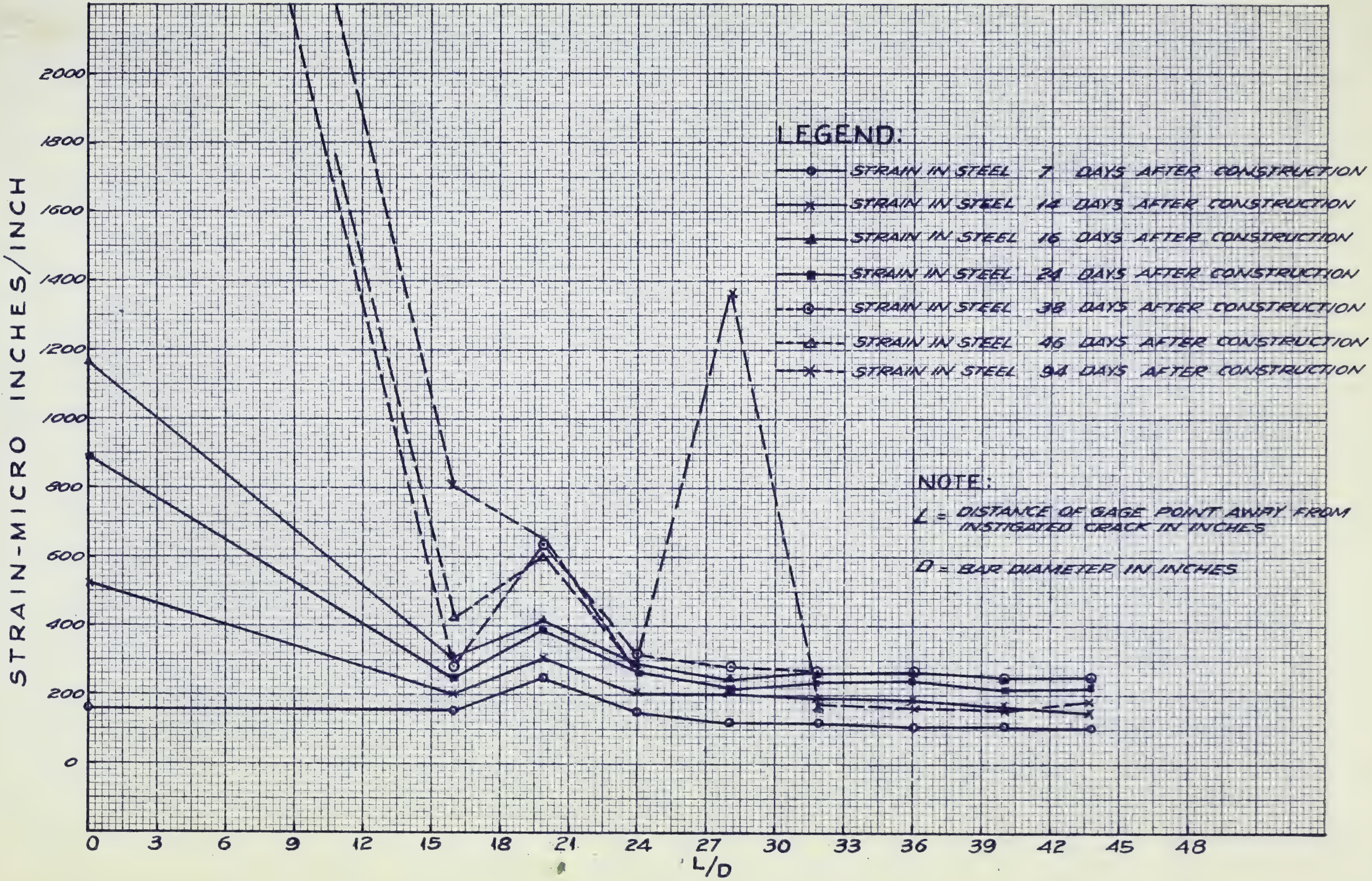


PLATE 8-7

CRACK WIDTH - TIME CURVES

SECTION TYPE B6-2 LOCATION VIII STATION 294+00

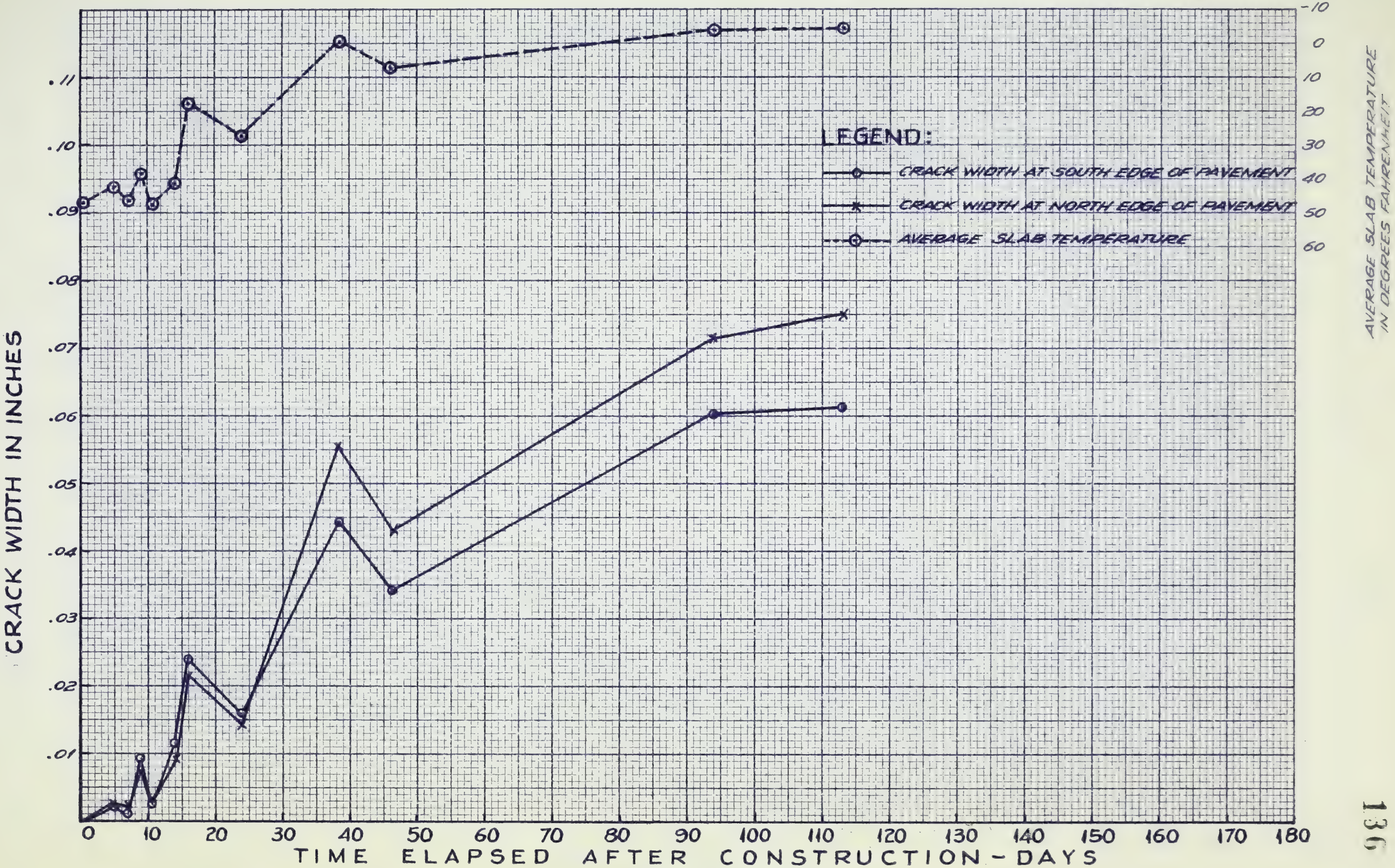


PLATE 8-8

STRAIN - CRACK WIDTH CURVE

SECTION TYPE B6-2 LOCATION VIII STATION 294+00

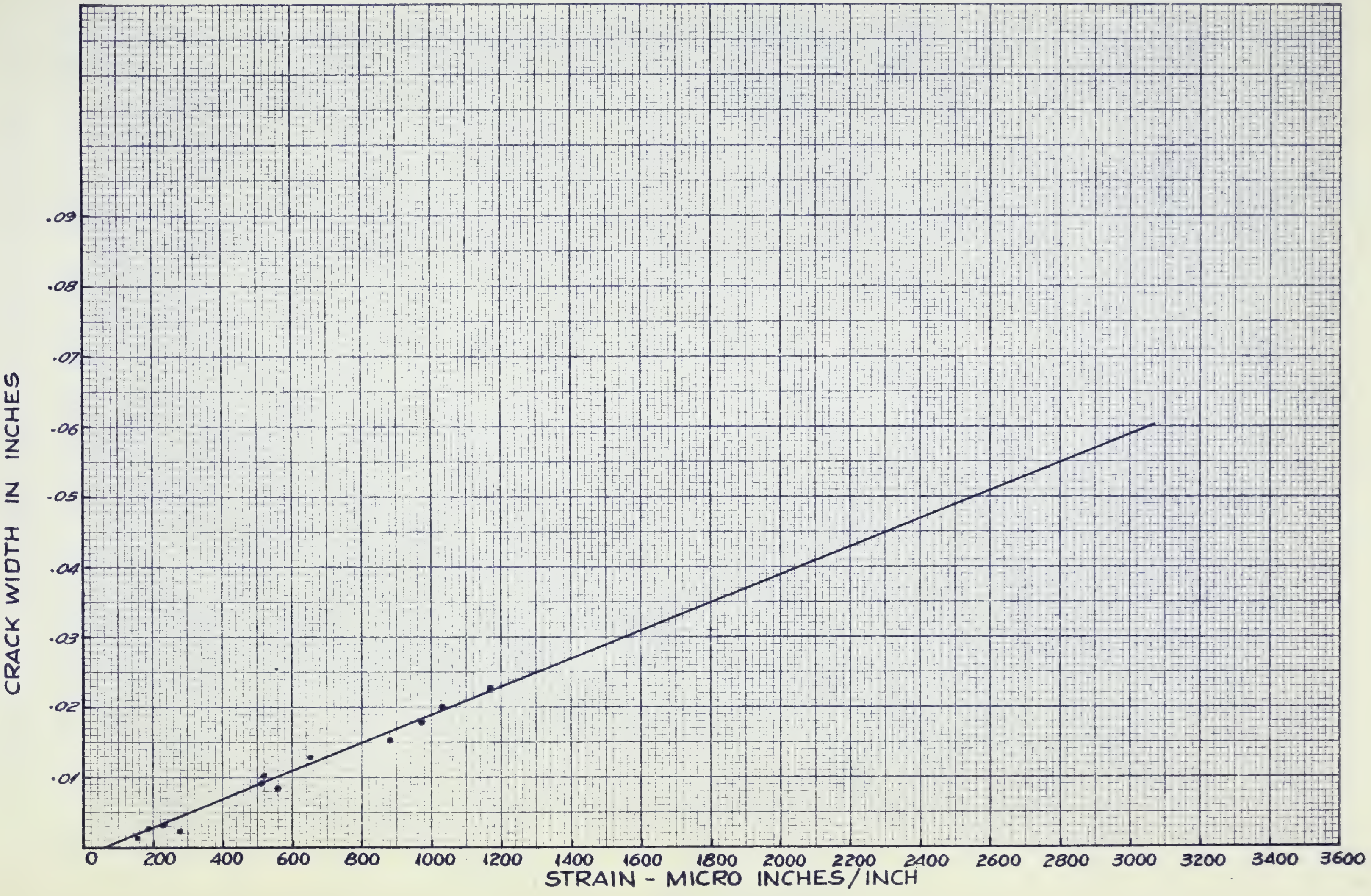


PLATE 8-9

SLAB TEMPERATURE - CRACK WIDTH CURVE

SECTION TYPE B6-2 LOCATION VIII STATION 294+00

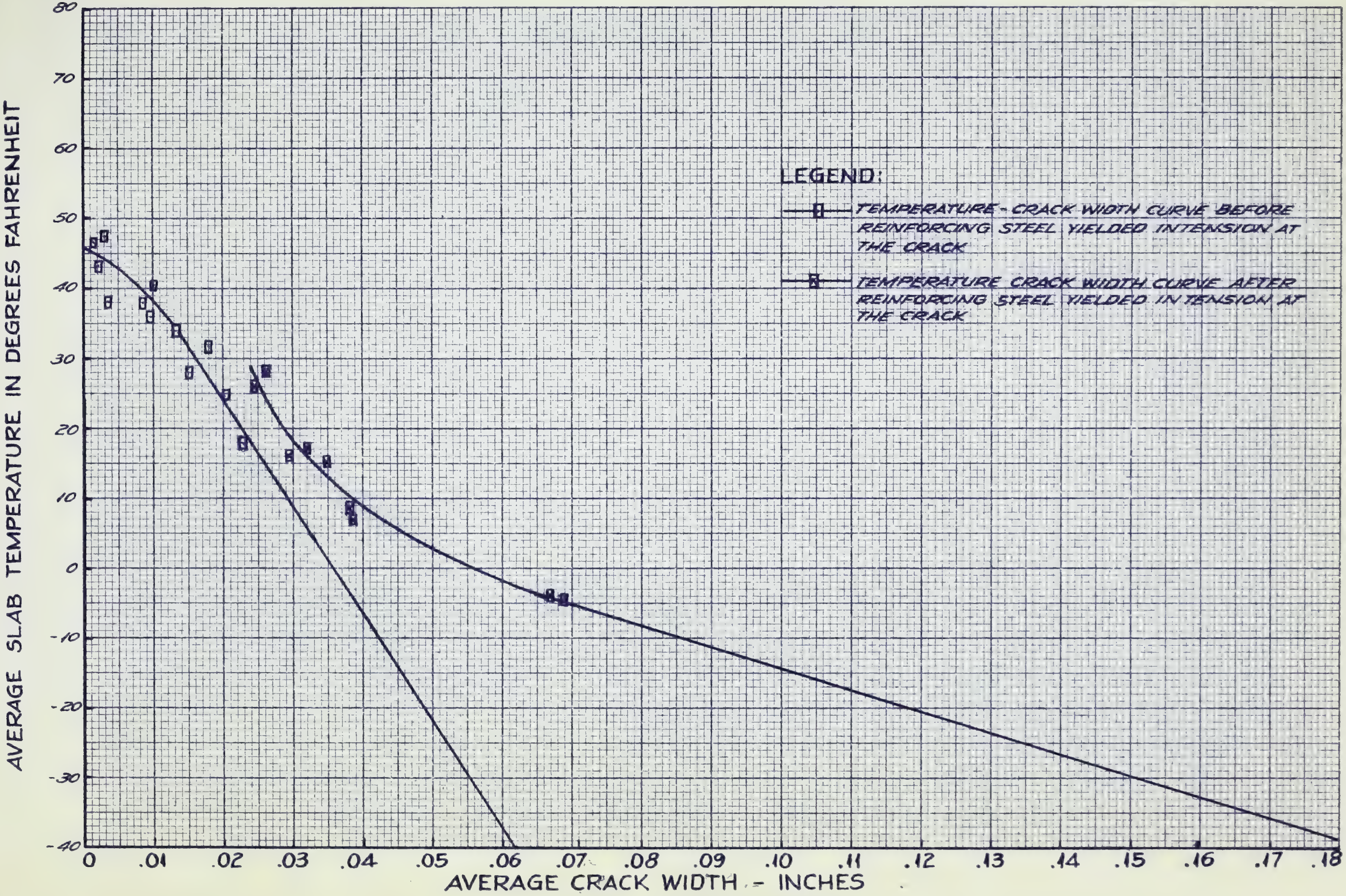


PLATE 8-10

TEMPERATURE - STRAIN CURVE

SECTION TYPE B6-2 LOCATION VIII STATION 294+00

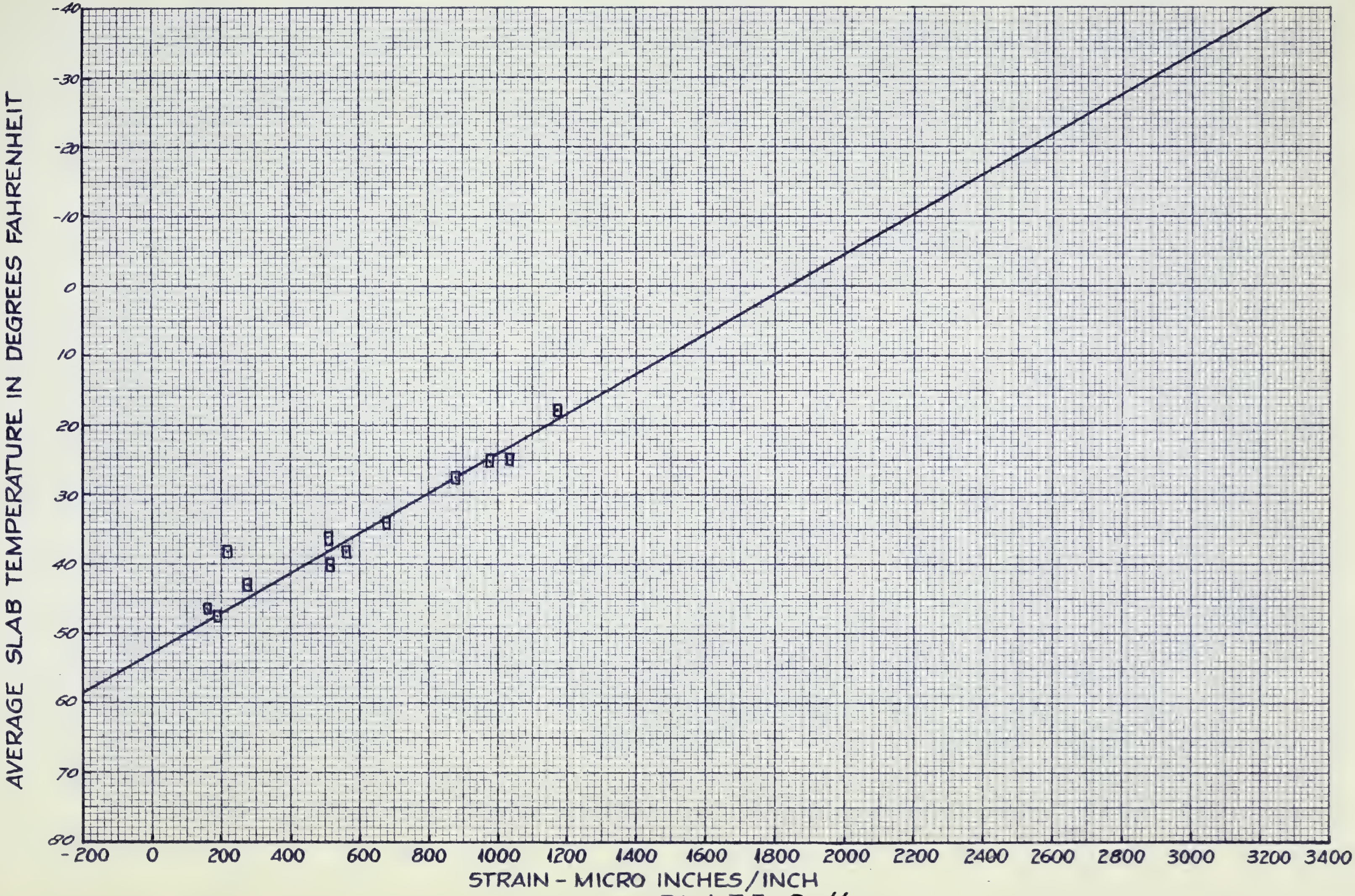


PLATE 8-11

SECTION TYPE B6-2

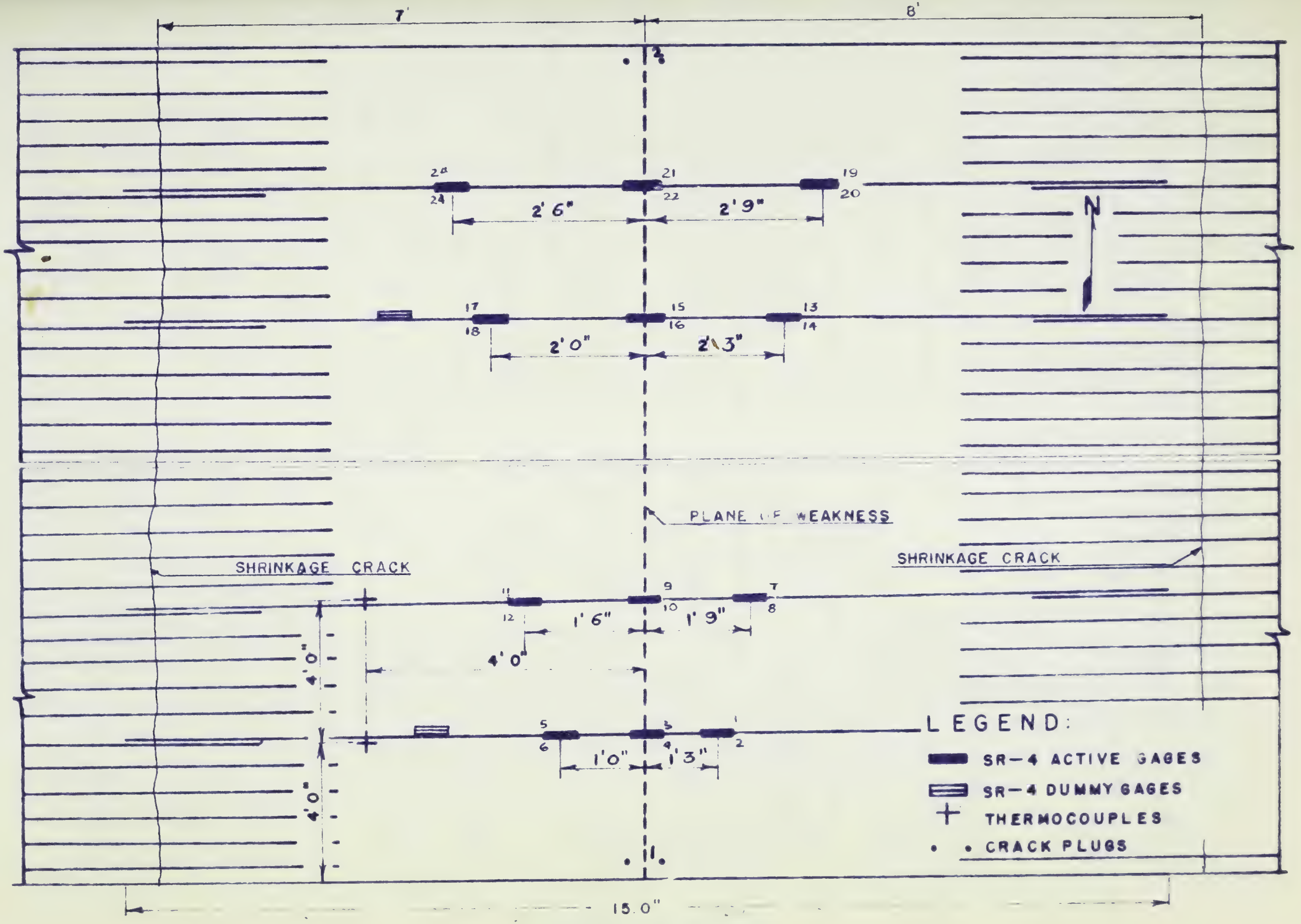


PLATE 8-12

(b) Location IX

The pavement was placed at the test section at 11 a.m. on October 20, 1958 when the air temperature was 50°F. The first set of readings was taken two hours after the finishing operation.

Curves in Plates 9-1 and 9-2 show the strain history in the reinforcing steel at the instigated crack. The strain history at the gage points at each side of the plane of weakness is shown in Plates 9-3 to 9-6 inclusive. The diagram in Plate 9-10 shows the position of the strain gages, crack plugs, temperature gages, and the location of the shrinkage crack which developed in the south lane east of the plane of weakness four days after construction. Strain data indicate that the shrinkage crack advanced into the north lane to the point shown in Plate 9-10 before the 46 day readings were taken. Subsequent measurements tend to indicate that this crack advanced to the position of the gage point 13-14 but not any further.

During the first two days after construction temperature fluctuations had only minor influence on the strain pattern of the reinforcing steel at the instigated crack, and at gage points on each side of the plane of weakness (Plate 9-9).

Measurements taken five days after construction when the slab temperature was 45°F indicate that the pavement cracked at the induced plane of weakness and another crack developed about 18 inches east of the plane of weakness in the south lane. These cracks developed as a result of shrinkage and sudden drop in temperature. It may be observed in Plates 9-1 to 9-4 that

the presence of the shrinkage crack east of the plane of weakness had a measurable effect on the future strain pattern at gage points 1-2, 3-4, 7-8, 9-10 and 13-14.

After the pavement was subjected to extremely low temperatures, the instigated crack became wider and the reinforcing bars at the crack were strained more evenly.

It must be pointed out that no yielding of reinforcing bars spanning the crack took place even at very low temperatures.

The data indicate that for a given increase in strain in the reinforcing steel and for a given drop in the slab temperature, the width of the instigated crack increased at a decreasing rate (Plates 9-7 and 9-8). Also, for a given drop in temperature, strain in the reinforcing bars at the crack increased at a diminishing rate.

Temperature records at the Calgary airport indicate that a low of -25°F. was recorded for the winter season. By extrapolation of the temperature-strain and crack width-strain curves, it may be shown that at this low in temperature, reinforcing steel at the crack was strained to 1,900 micro inches/inch, the approximate yielding strain, and the width of the crack probably opened to 0.043 inches.

In order to explain the pavement behaviour at this location it is necessary to review the basic theory for the continuously reinforced concrete pavements.

Temperature contraction of short pavement slabs is not greatly diminished by frictional tension stress, but long pavement slabs as used in continuously reinforced concrete

pavements actively contract and expand for some hundreds of feet near each end. The length of actively moving ends and the relative movements are related to the thermal change, the coefficient of friction, and the modulus of elasticity of the pavement. Movements for daily temperature changes extend in diminishing amounts to a distance of a few hundred feet from the free ends until a point of zero movement is reached. The length of the actively moving end extends from the free end of the continuously reinforced concrete strip to a point at which the total frictional force is equal to the elastic potential force of the reinforcing steel(6). This is illustrated in Plate 10.

The length of the central portion of the pavement extending from Y to Z remains constant, while the length of the pavement extending from A to Y and from B to Z changes in length due to movement which is caused by shrinkage and temperature fluctuation (Plate 10).

The fact that the strain in the reinforcing steel remained in the elastic range and the crack did not open to an objectionable width, tends to indicate that the length of the actively moving end extended from the expansion dam constructed at the east end of the continuously reinforced concrete strip to a point some distance beyond the test section at this location.

Conclusions

The presence of the shrinkage crack, a short distance east of the plane of weakness, had measurable effect on the strain pattern in the reinforcing bars located in the south lane of the pavement. Moreover, at extremely low temperatures, the strain in the reinforcing bars across the instigated crack distributed itself more evenly and the crack east of the induced plane of weakness became inactive.

During the first few days temperature fluctuations had only minor influence on the strain pattern in the reinforcing steel. A constant temperature cycling when the concrete was weak prevented formation of an adhesive bond between the concrete and the reinforcing bars, and only mechanical bond developed at the extreme limits of differential movement between the concrete and the deformations on the reinforcing bar.

There is some evidence which leads to the belief that the length of actively moving end extended some distance west of the test section at Location IX.

The apparent differential movement between the concrete slab and the base during the cooling cycle prevented the cracks from opening up to objectionable widths and the reinforcing bars at the crack from yielding in tension.

(c) Comparison of Results at Test Sections in Pavement Type B6-2

During the first twenty-four days after construction when the slab temperature remained above 20°F., similar pavement behaviour was observed at the two test sections with some minor variations in strain in the reinforcing bars and width of the crack opening. The reinforcing bars were subjected to higher strains at the crack at Location VIII and the induced crack opened wider at Location IX. Low temperature had a much different effect on the strain pattern and the crack opening at the two respective locations.

With the approach of the sub-zero temperatures, reinforcing steel at Location VIII yielded in tension and the crack opened to an objectionable width (an eighth of an inch). At Location IX, the relative slab movement which accompanied the temperature drop prevented a large crack opening, and the reinforcing steel from straining past the yield point.

The loss of bond at both locations extended to a point about 16 bar diameters from the instigated crack at both test sections. When the reinforcing steel strained beyond the yield point, the loss of bond at Location VIII extended to a point about 32 bar diameters from the instigated crack.

STRAIN—TIME CURVES

SECTION TYPE B6-2 LOCATION IX STATION 289+50

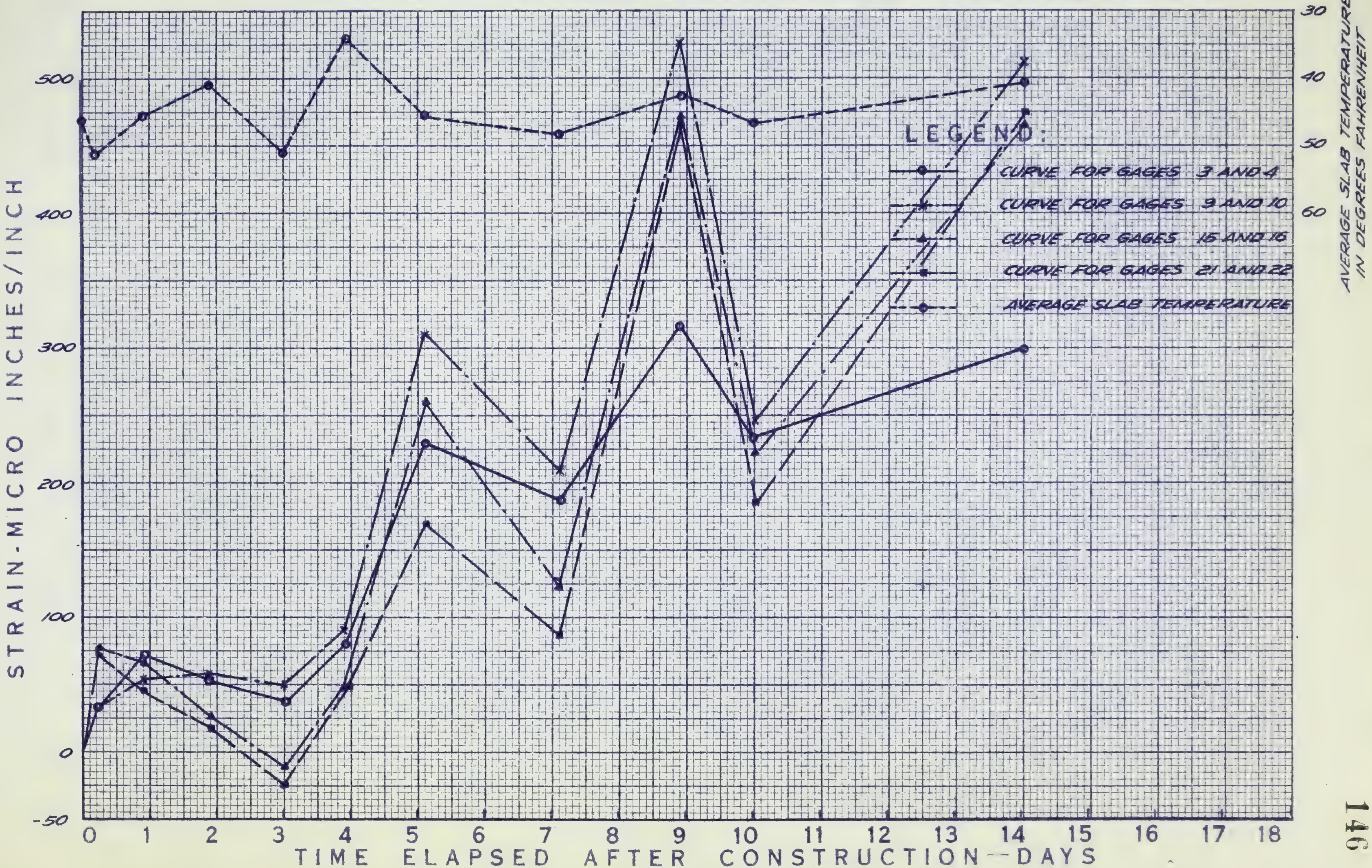


PLATE 9-1

STRAIN–TIME CURVES

SECTION TYPE B6-2 LOCATION IX STATION 289+50

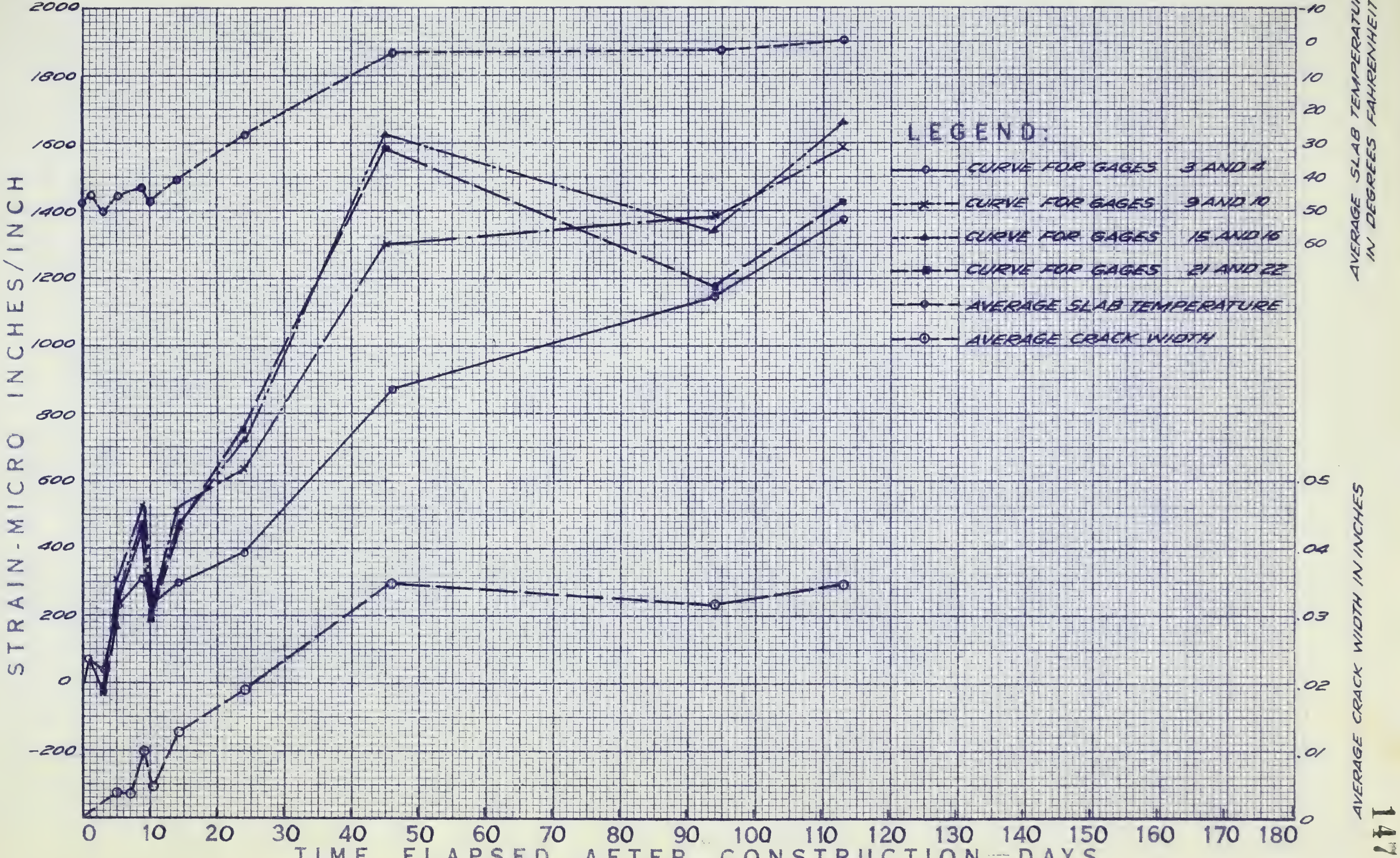


PLATE 9-2

STRAIN—TIME CURVES

SECTION TYPE B6-2 LOCATION IX STATION 289+50

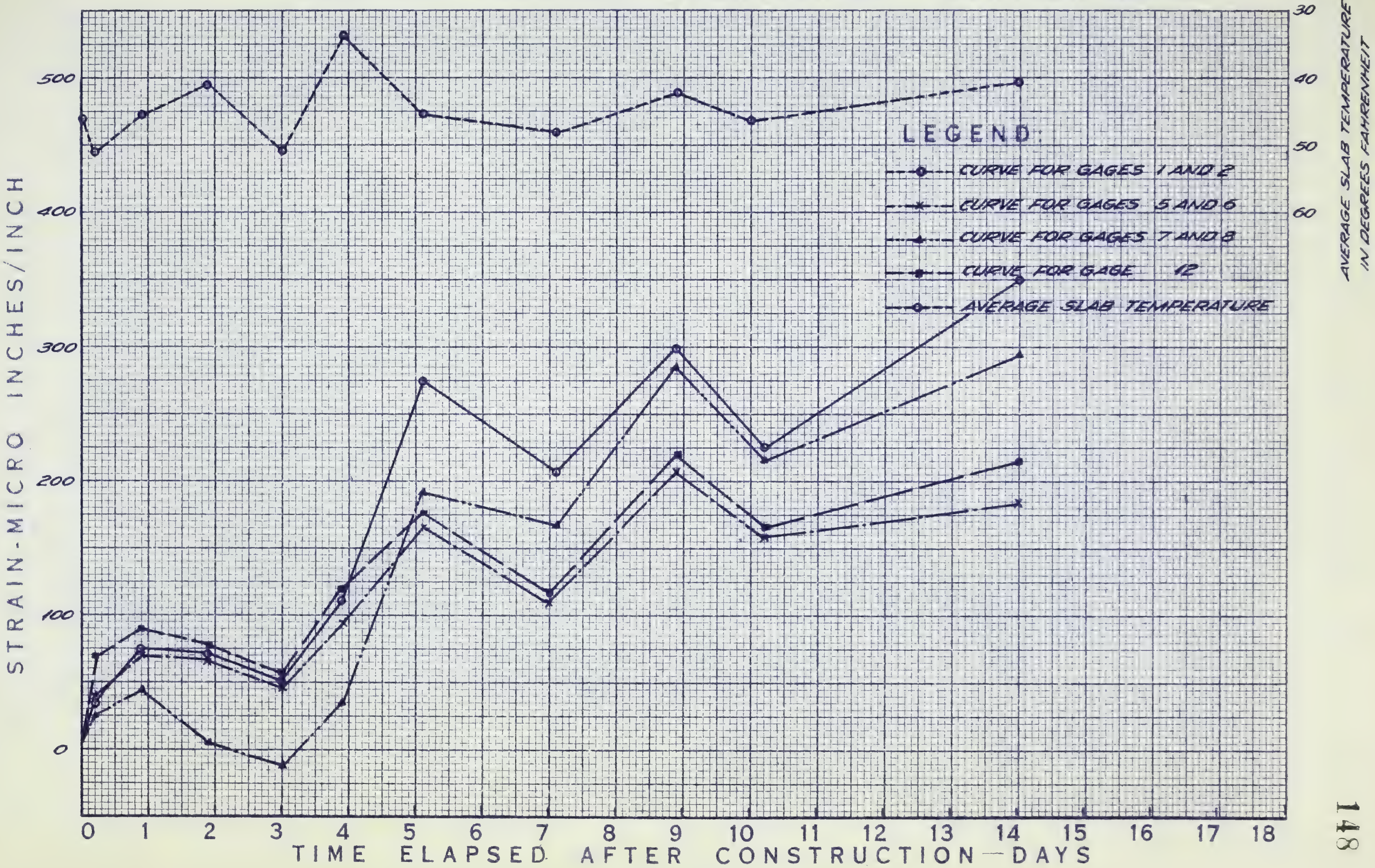


PLATE 9-3

STRAIN — TIME CURVES

SECTION TYPE B6-2 LOCATION IX STATION 289+50

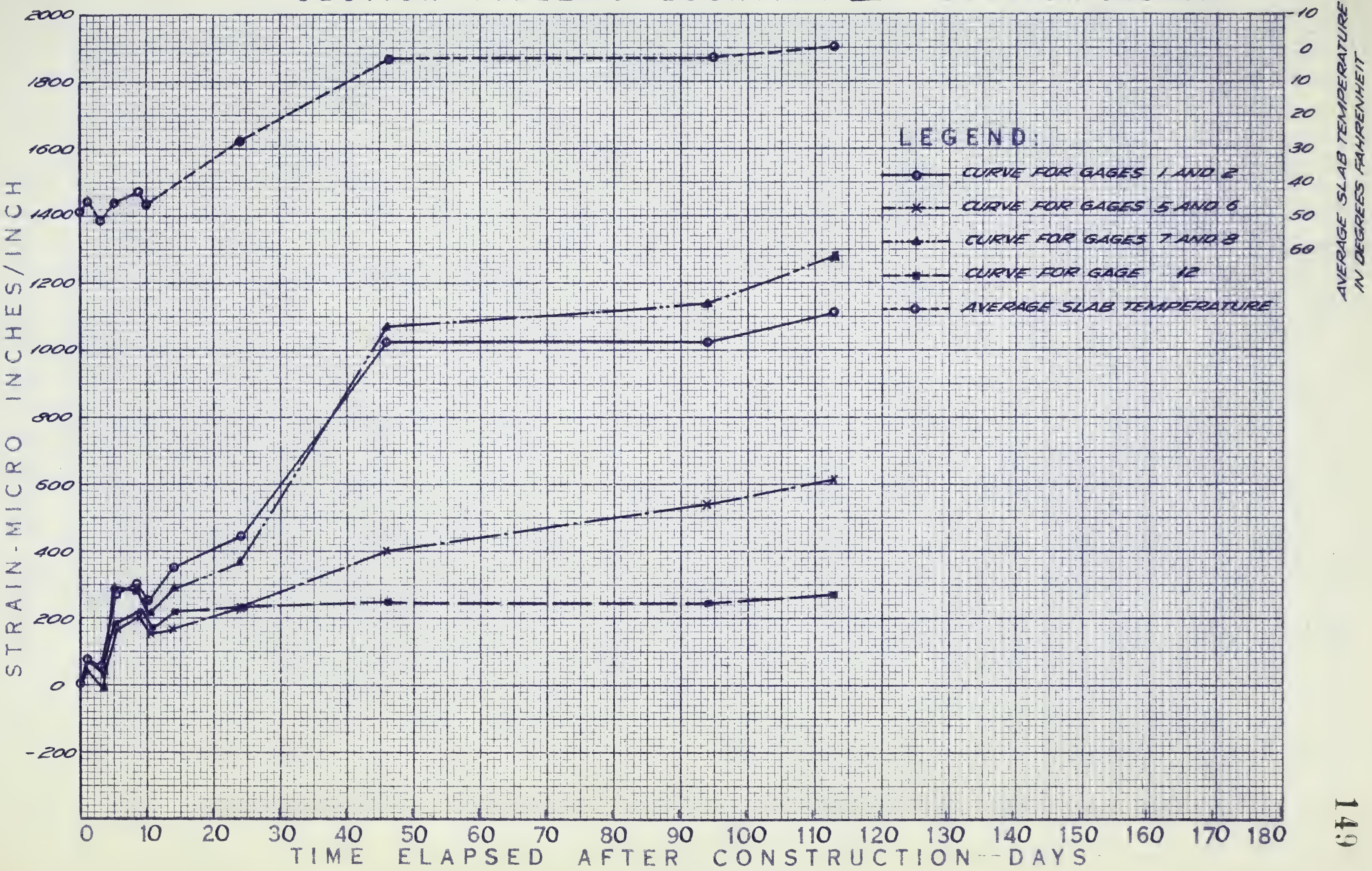


PLATE 9-4

STRAIN – TIME CURVES

SECTION TYPE B6-2 LOCATION IX STATION 289+50

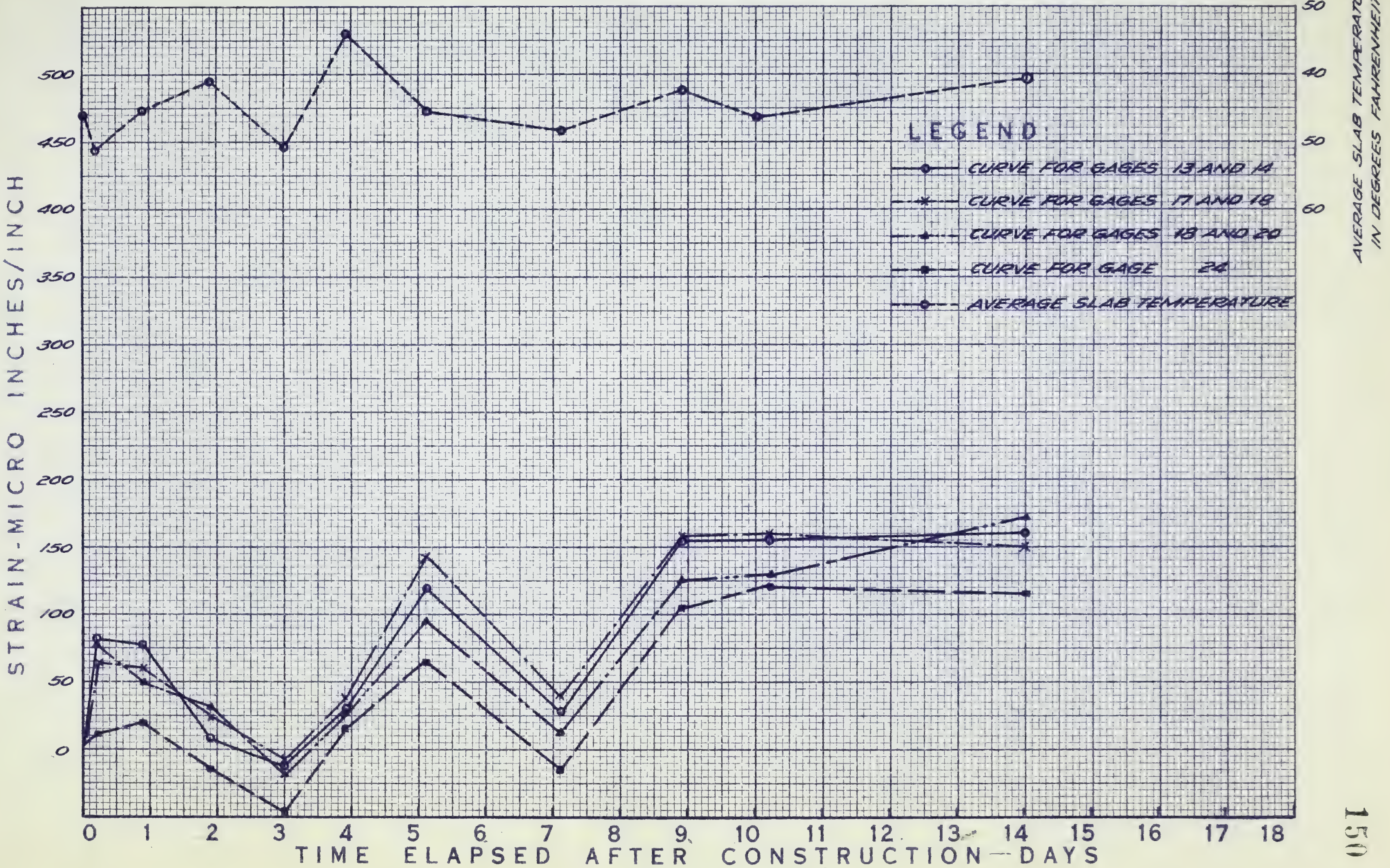


PLATE 9-5

STRAIN - TIME CURVES

SECTION TYPE B6-2 LOCATION IX STATION 289+50

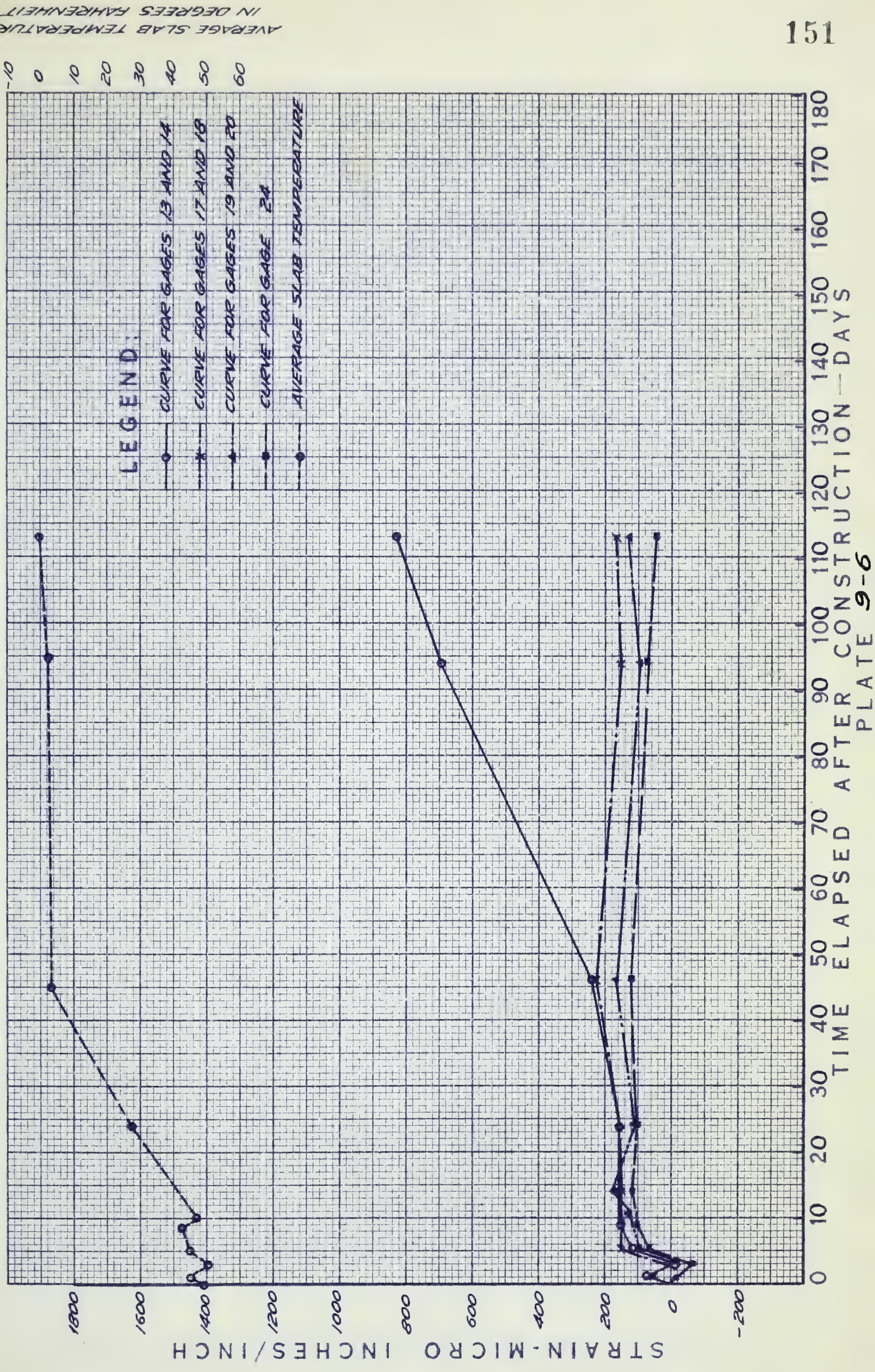


PLATE 9-6

TEMPERATURE-CRACK WIDTH CURVE

SECTION TYPE B6-2 LOCATION IX STATION 289+50

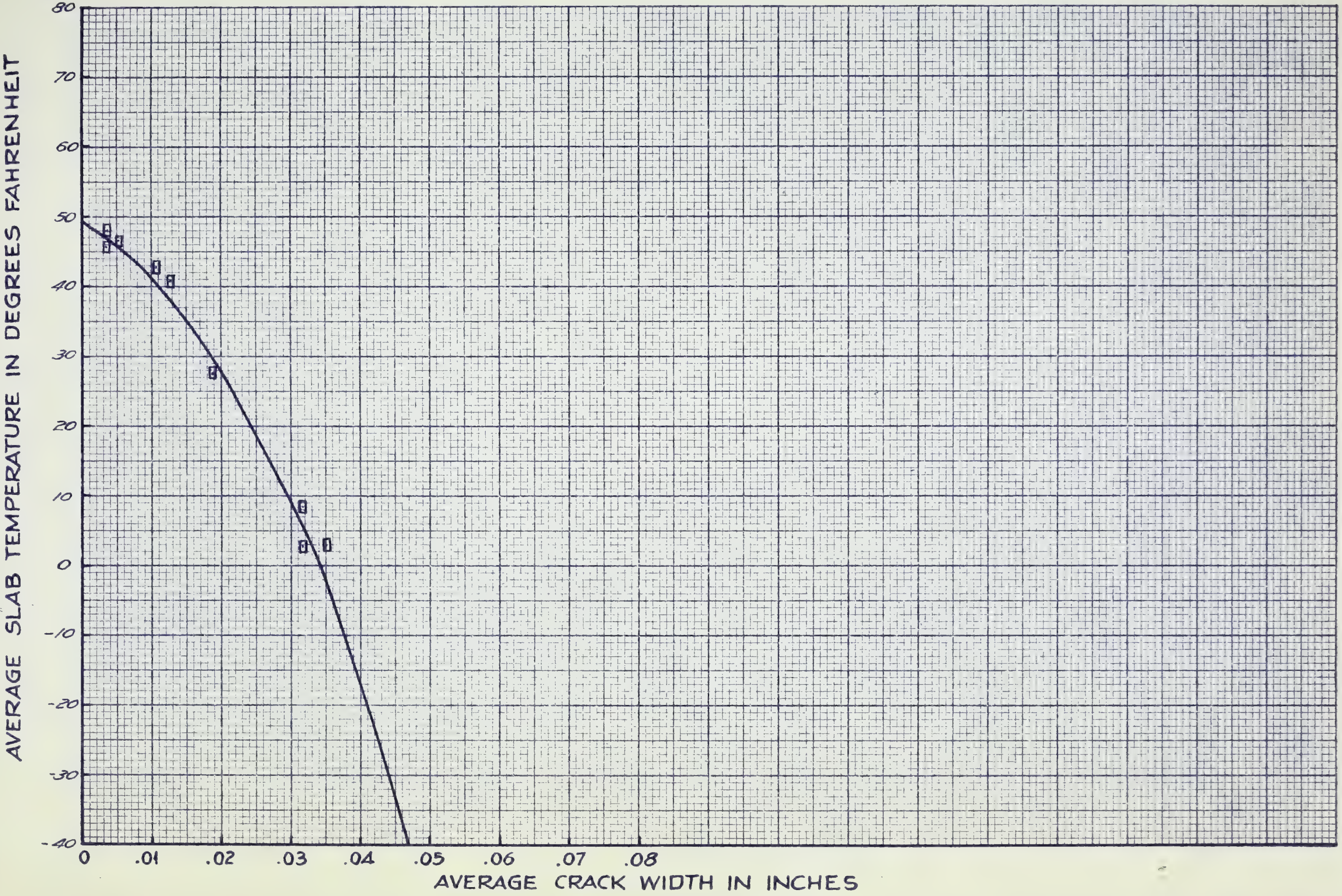


PLATE 9-7

TEMPERATURE - STRAIN CURVE

SECTION TYPE B6-2 - LOCATION IX STATION 289+50

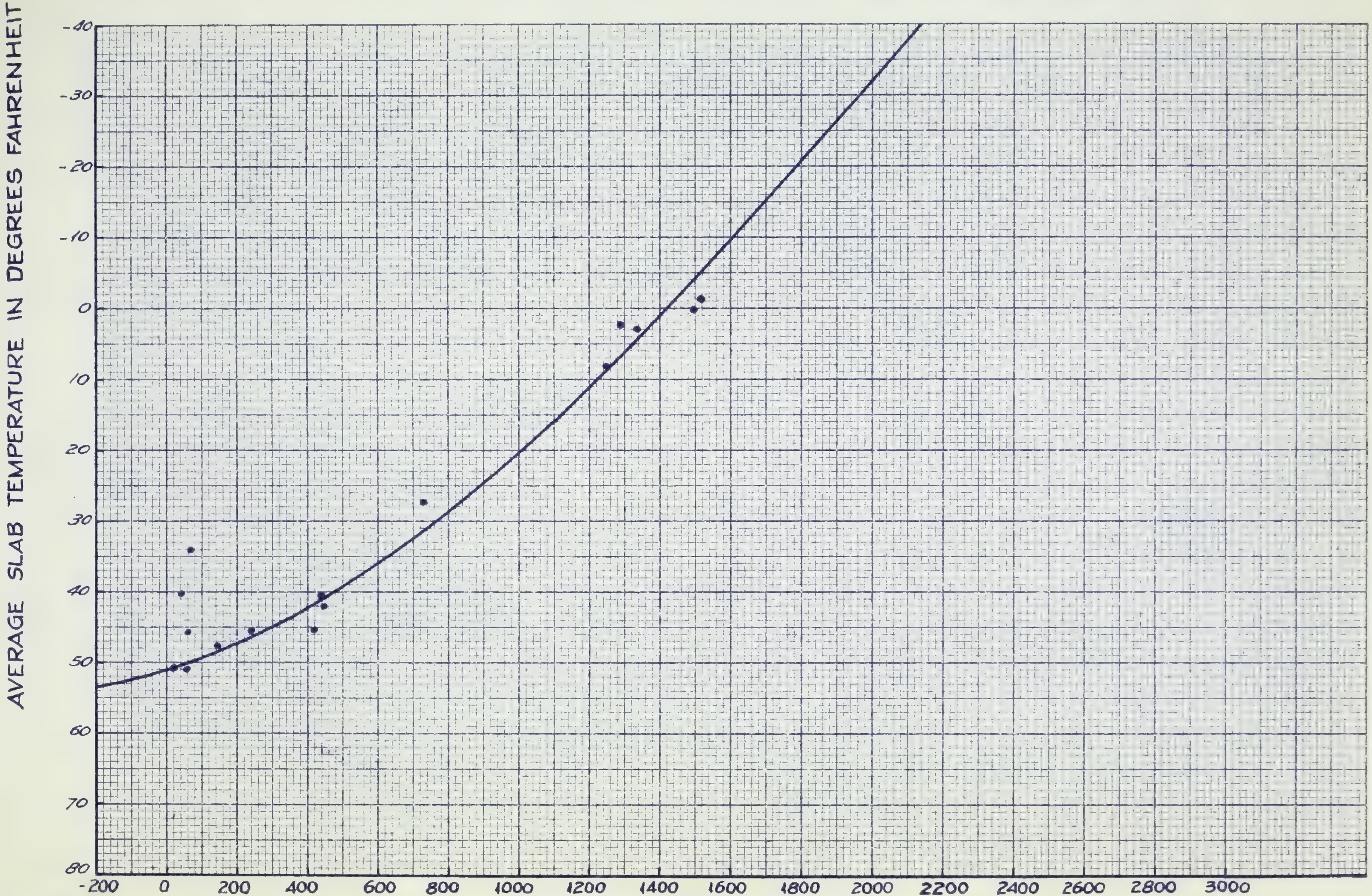


PLATE 9-8

STRAIN - CRACK WIDTH CURVE

SECTION TYPE B6-2 LOCATION IX STATION 289+50

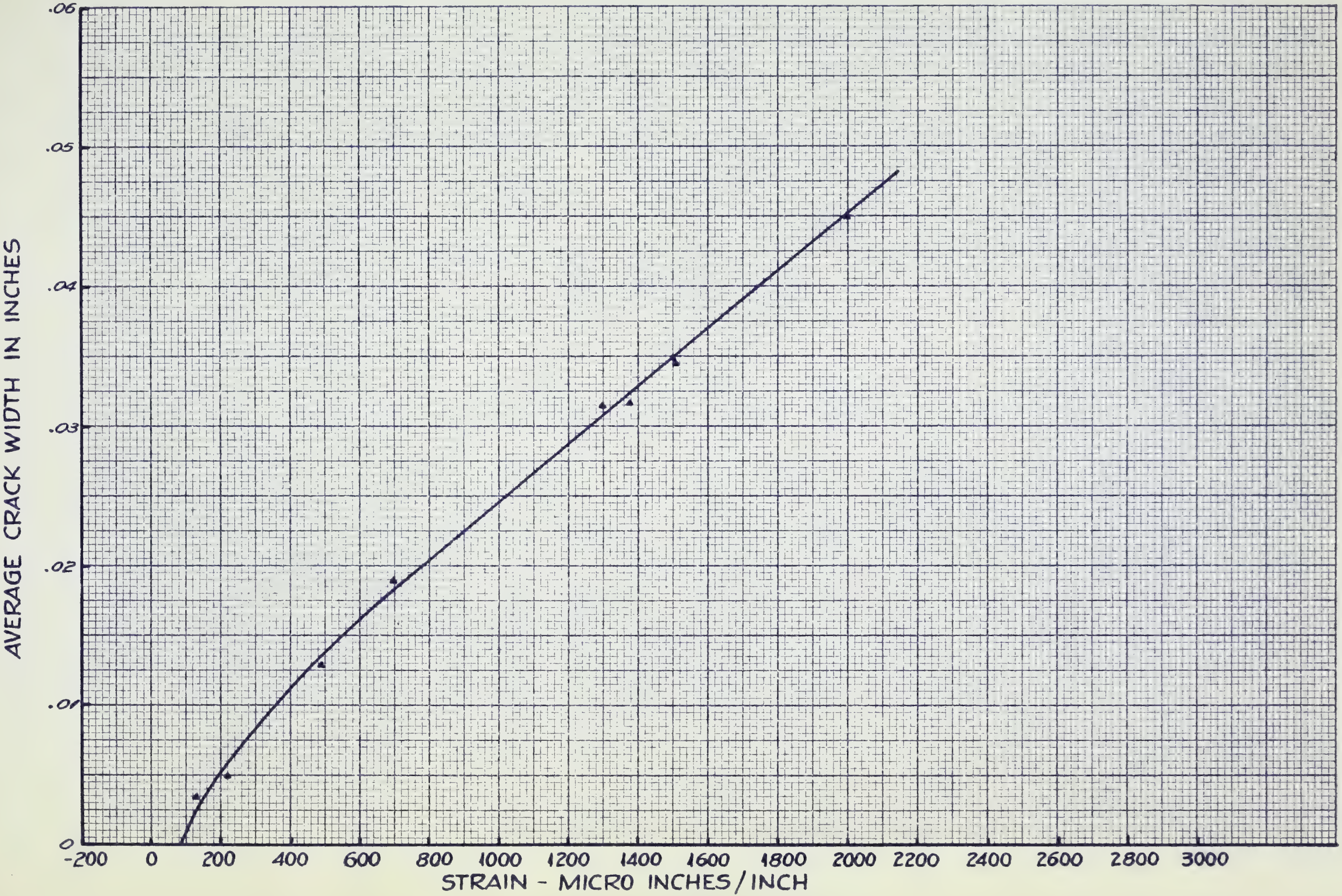


PLATE 9-9

SECTION TYPE B6-2

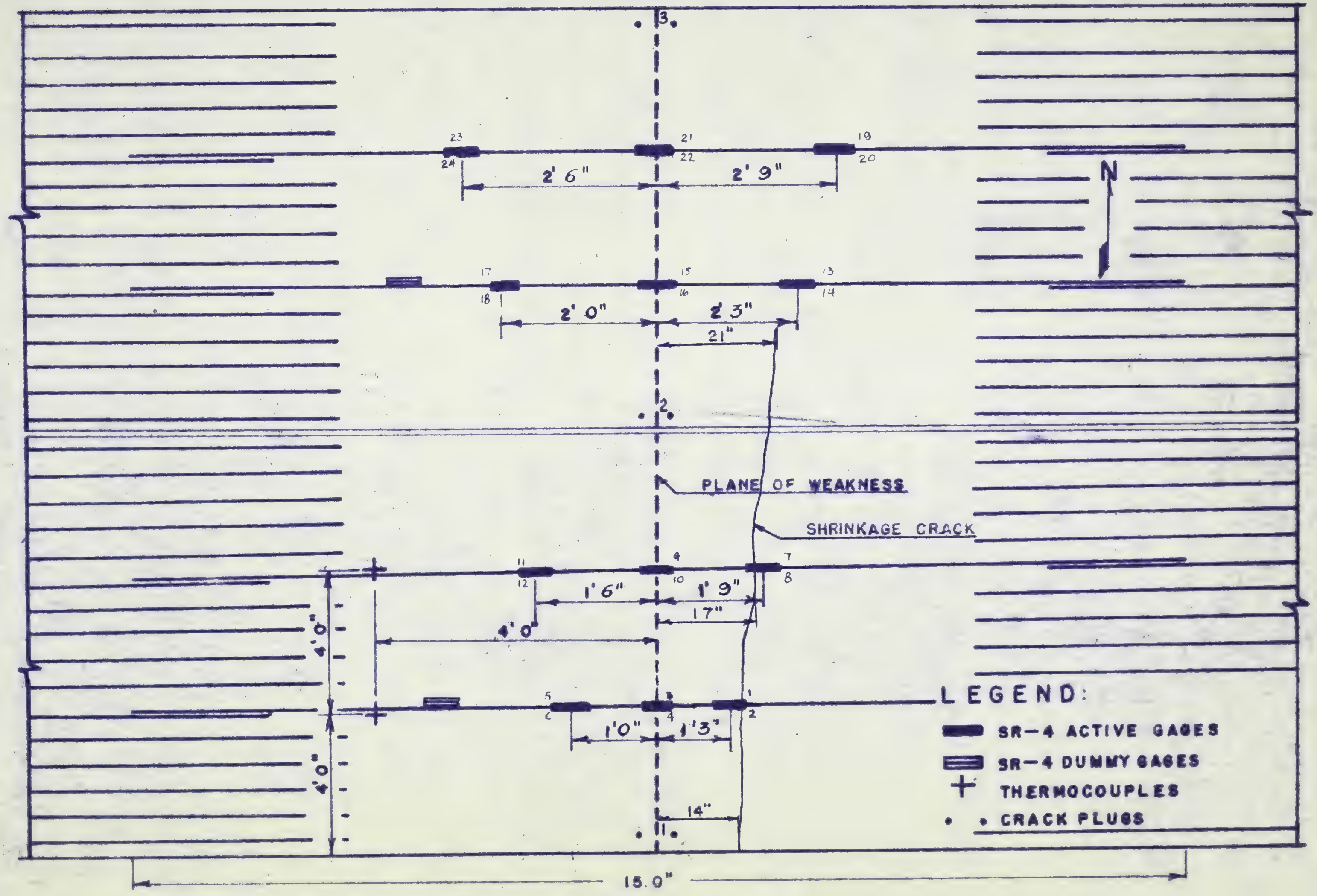


PLATE 9-10

B. Reinforced Concrete Pavement with Joints Spaced at 30 Feet

Section Type A-6

The reinforced concrete pavement with contraction joints spaced at 30 foot intervals, Type A-6, 2,610 feet in length consists of a six-inch slab reinforced in longitudinal direction with No. 4 intermediate grade deformed steel bars, comprising a 0.185% of the cross-section area of the pavement (for full details see Plate 4). One test section referred to from here on as "Location X" was located at station 262+50.

The pavement was poured at the test section on October 28, 1958. The first set of readings was taken about three hours after the finishing operation. These provided the basis for all subsequent strain calculations.

A crack at the induced plane of weakness developed before the pavement was three days old. Measurements made 3.2 days after construction indicated that strain in the reinforcing steel reached 1,320 micro inches/inch and the width of the crack opened to 0.022 inches. The slab temperature at the time of reading was 45°F. Measurements were made 7.3 days after construction when the slab temperature was 30°F. The strain in the reinforcing steel reached 1,900 micro inches/inch and the width of the instigated crack increased to 0.048 inches. Measurements taken 6 hours later when the slab temperature dropped to 28°F. showed a considerable decrease in strain in the reinforcing steel and the width of the instigated crack indicating that sufficient force was developed in the steel to cause

movement of the slab. Subsequent measurements tend to indicate that width of the crack and strain in the reinforcing steel increased with a drop in temperature until a sufficient force was developed in the reinforcing steel at the crack to cause additional slab movement. Plates 10-7 and 10-8 verify this type of action.

The loss of bond between the concrete and the reinforcing bars extended to a point between 24 and 30 bar diameters on each side of the crack (Plates 10-3 to 10-6 inclusive). Gages located on the bars at a distance greater than two feet on each side of the crack indicated some compression when the strain in the reinforcing steel at the crack remained in the low elastic range.

Conclusions

The loss of bond between concrete and the steel extended to a point about 24 bar diameters on each side of the instigated crack.

The strain in the reinforcing bars reached the yield point range, at which point sufficient force was developed in the steel at the crack to cause initial movement, closing the crack. Subsequent to this, additional movement occurred whenever the reinforcing steel was strained into high elastic range.

STRAIN-TIME CURVES

SECTION TYPE A-6 LOCATION X STATION 262+50

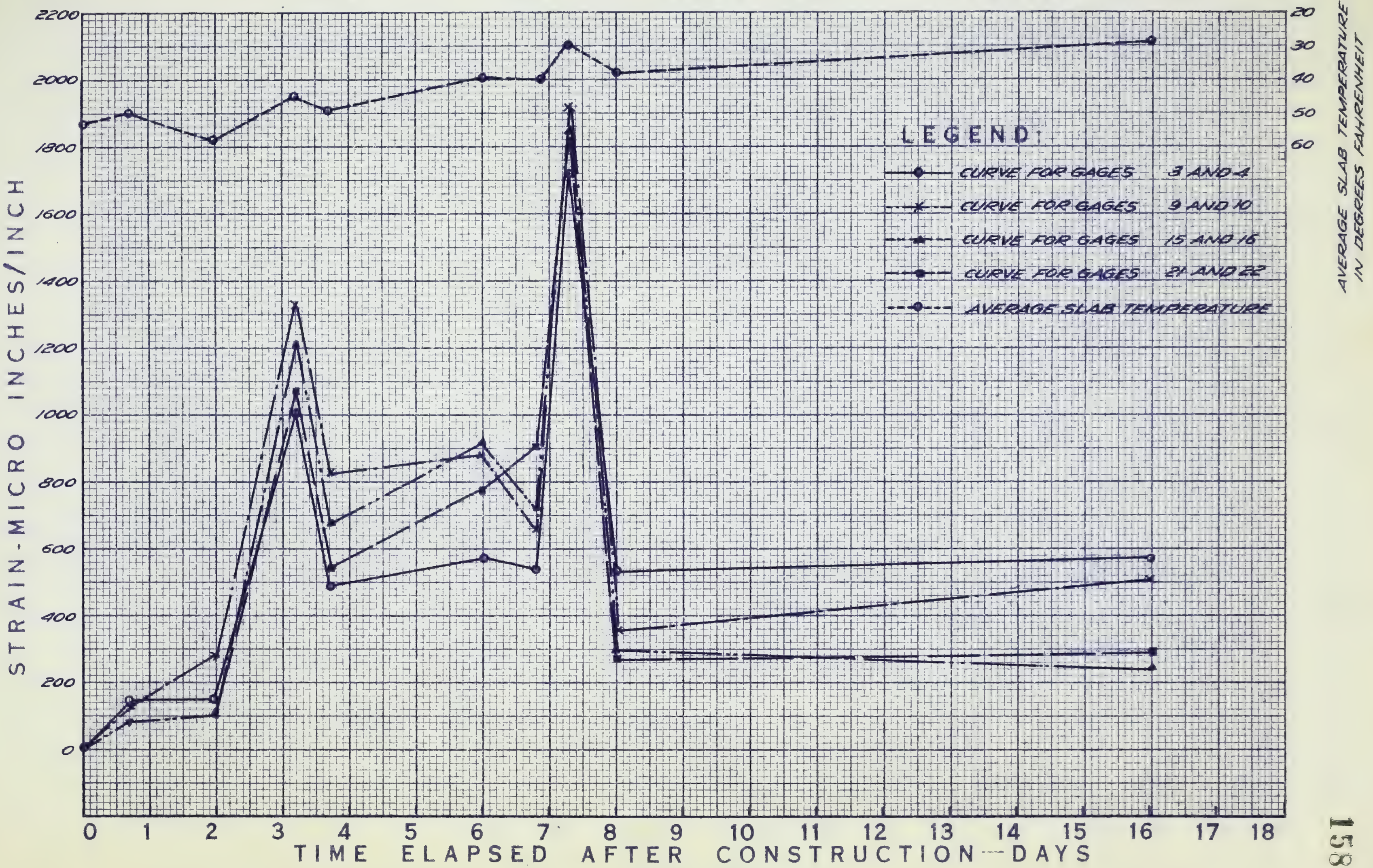


PLATE 10-1

STRAIN TIME CURVES

SECTION TYPE *A-6* LOCATION *X* STATION *362+50*

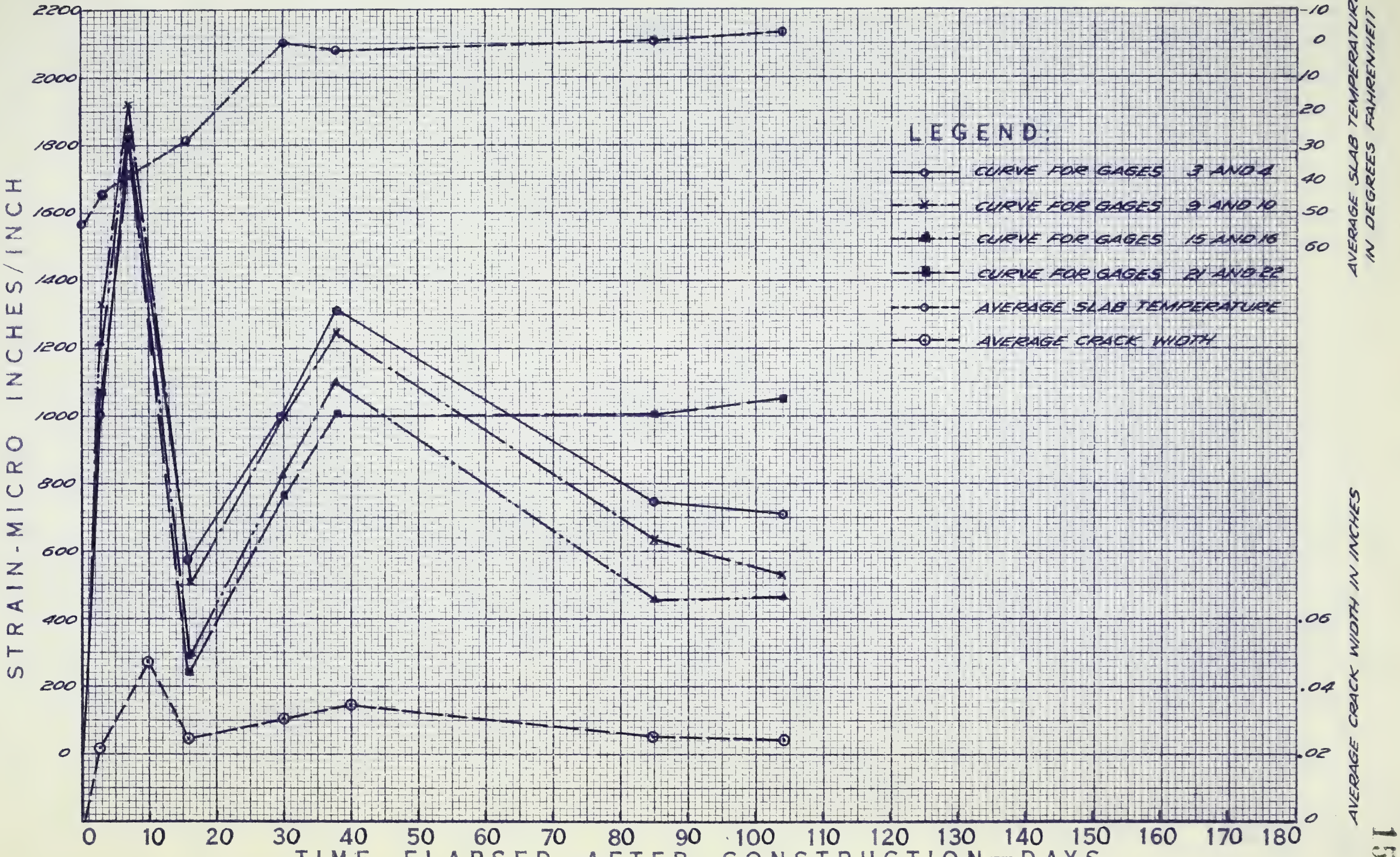


PLATE *10-2*

STRAIN TIME CURVES

SECTION TYPE A-6 LOCATION X STATION 262+50

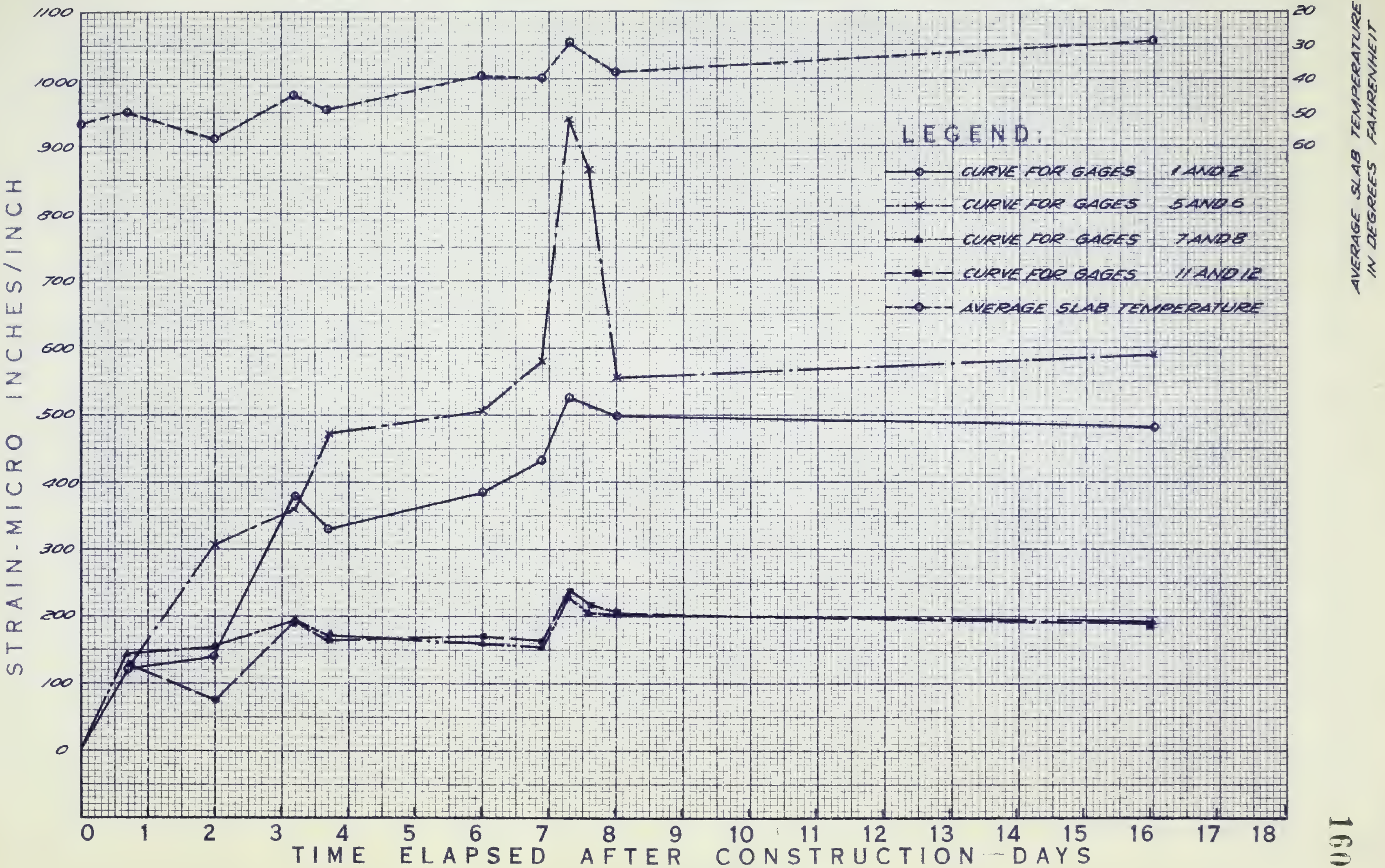


PLATE 10-3

STRAIN-TIME CURVES

SECTION TYPE A-6 LOCATION X STATION 262+50

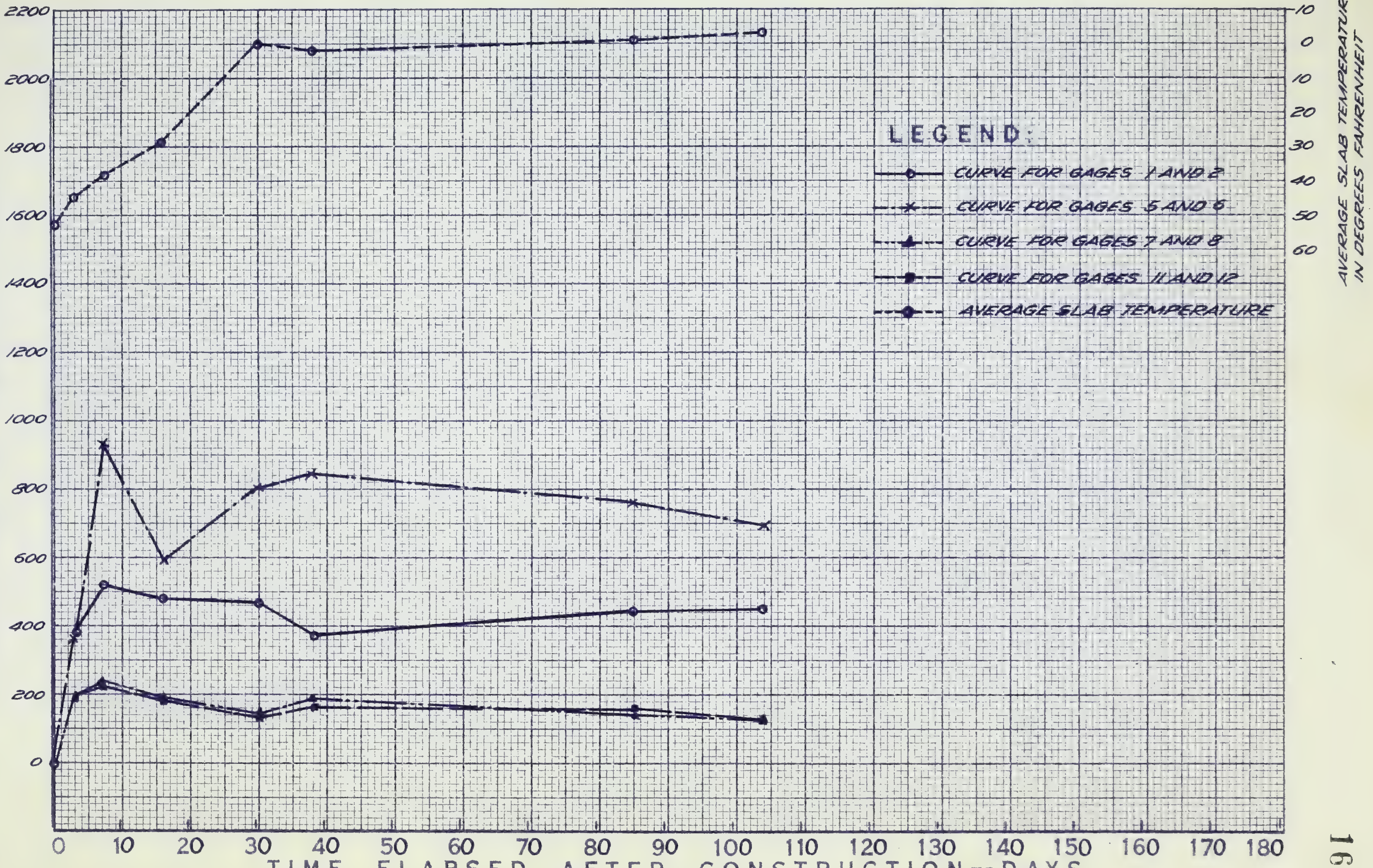


PLATE 10-4

STRAIN–TIME CURVES

SECTION TYPE A-6 LOCATION X STATION 262+50

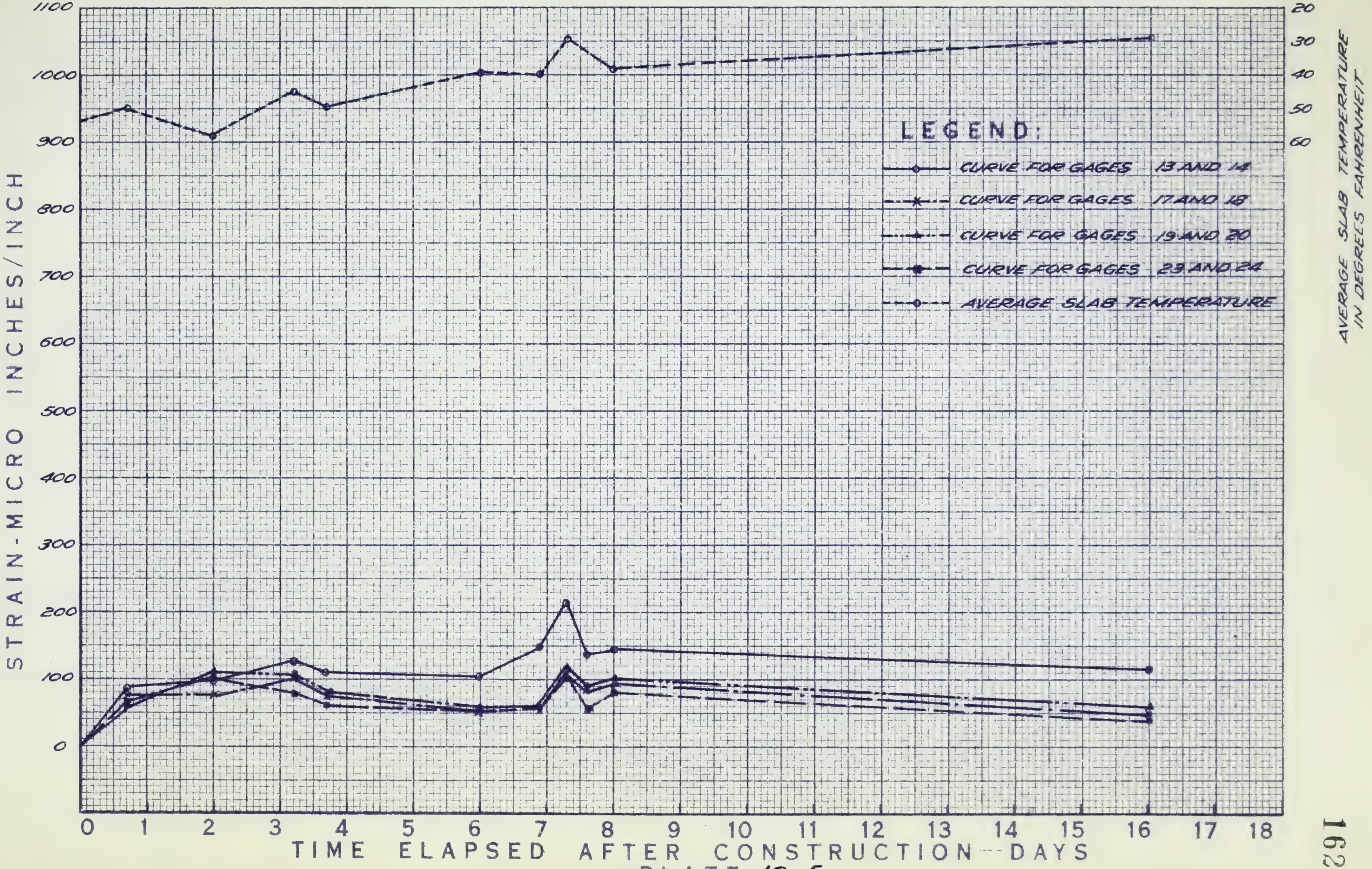


PLATE 10-5

STRAIN TIME CURVES

SECTION TYPE A-6 LOCATION X STATION 262+50

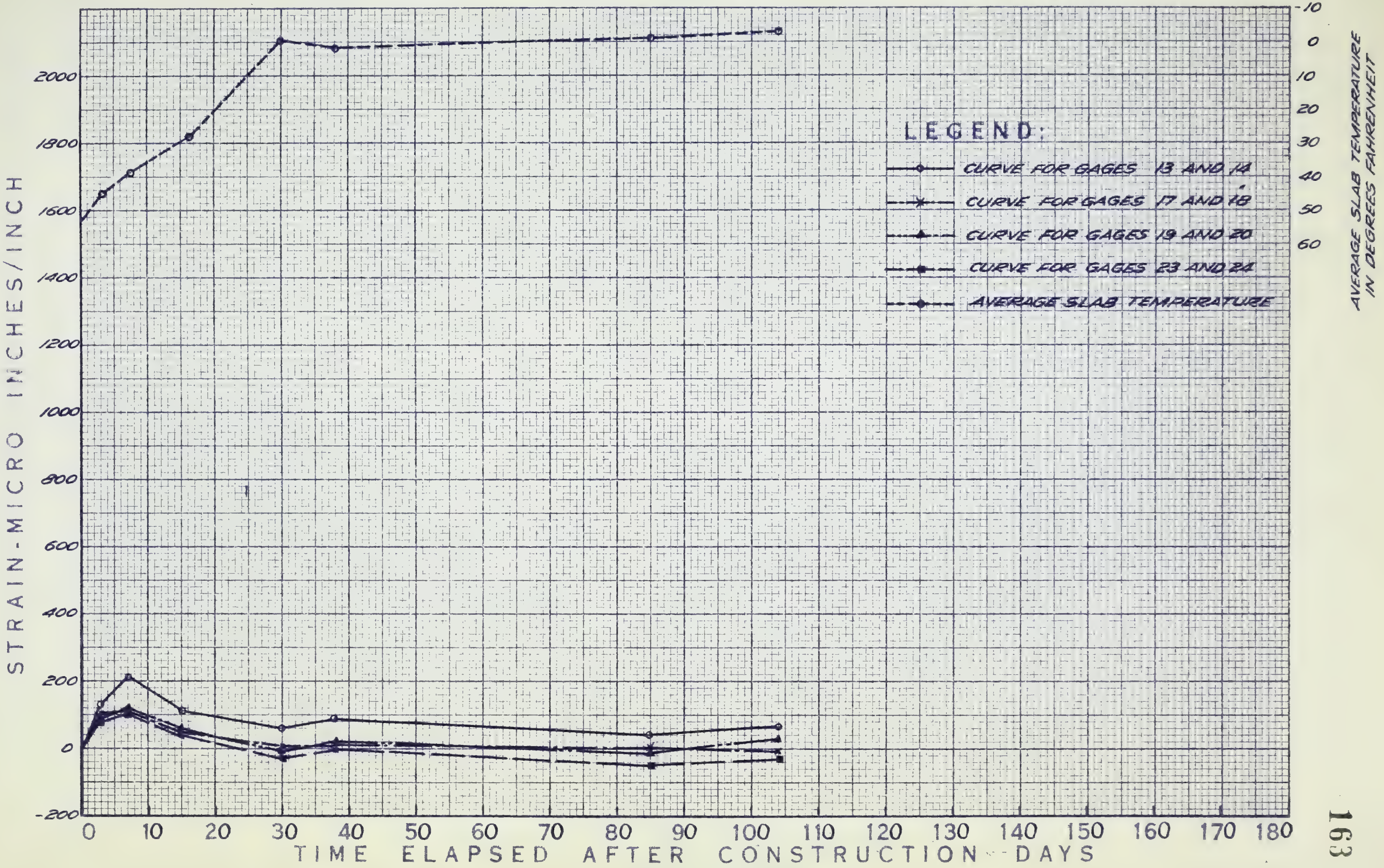


PLATE 10-6

TEMPERATURE - CRACK WIDTH

SECTION TYPE - A-6 LOCATION X STATION 262+50

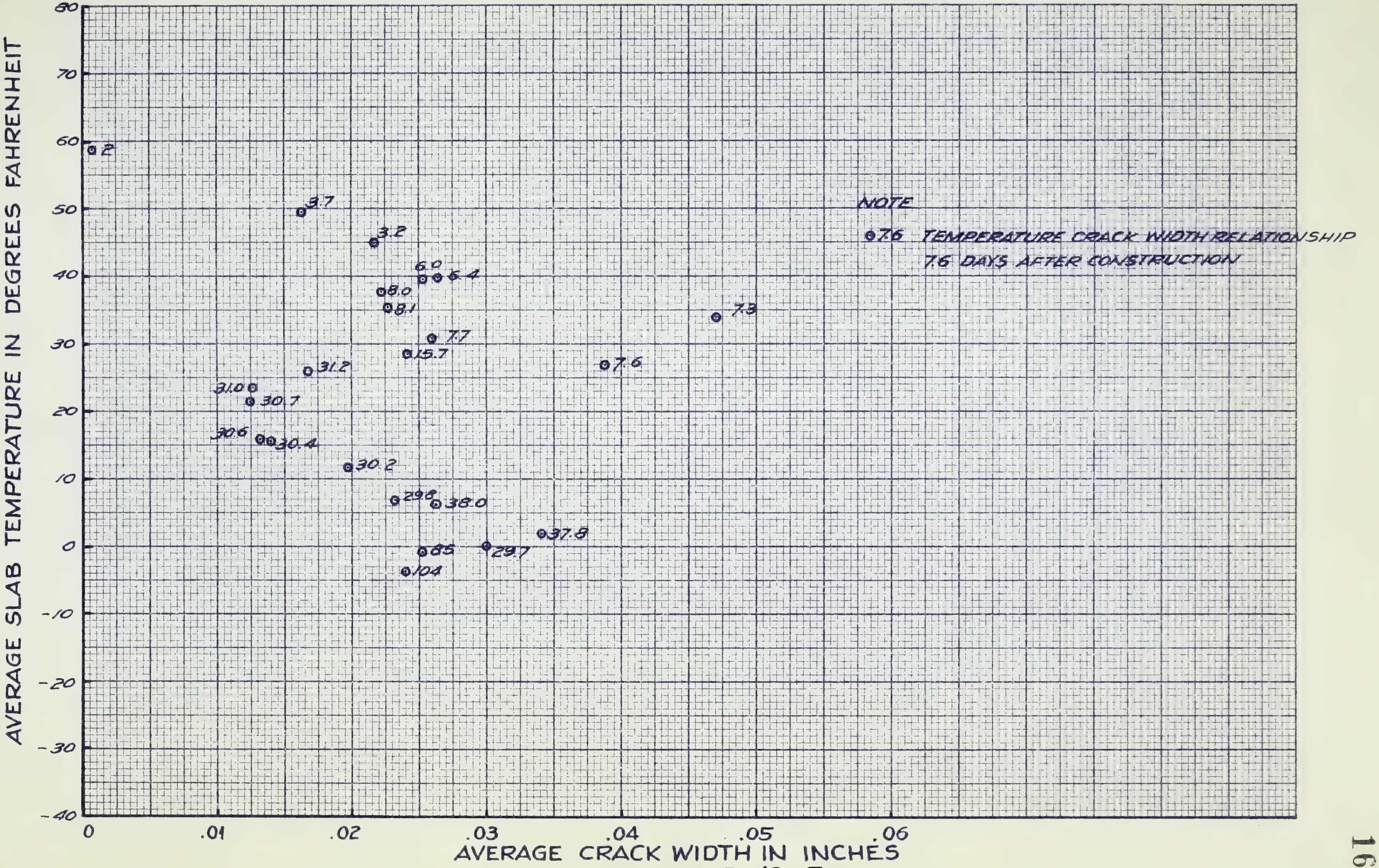


PLATE 10-7

TEMPERATURE - STRAIN

SECTION TYPE A-6 LOCATION X STATION 262+50

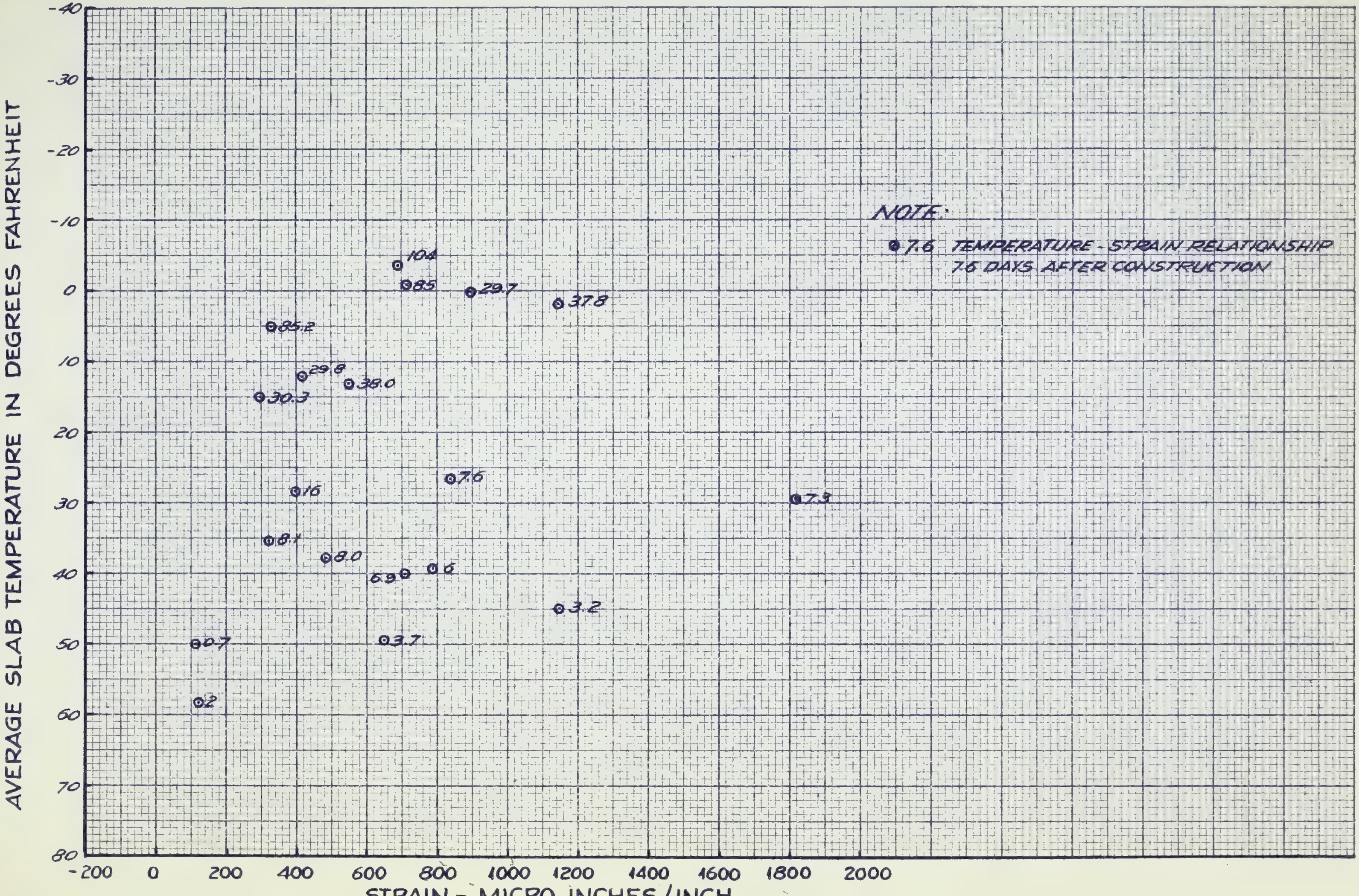


PLATE 10-8

SECTION TYPE A-6

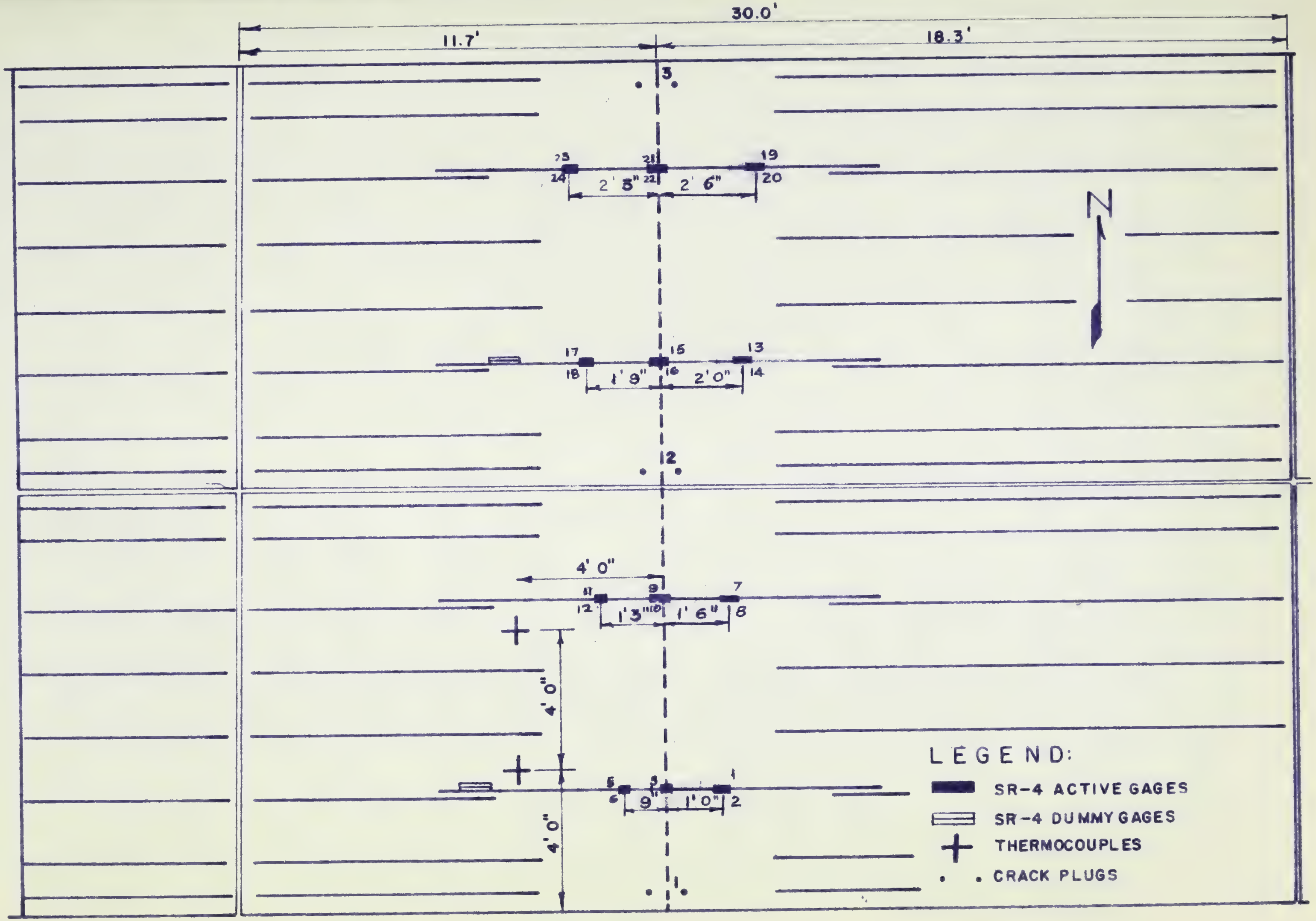


PLATE 10-9

IX. GENERAL OBSERVATIONS

1. The first cracks developed due to shrinkage.
2. Very few additional cracks developed as a result of extremely low temperatures.
3. The average crack spacing throughout the entire continuously reinforced pavement as of March 7, 1959 was from eight to ten feet.
4. At extremely low temperatures, cracks at some locations opened to widths exceeding one-eighth of an inch.
5. The cracks at the induced planes of weakness developed three to five days after construction.
6. Results presented indicate that temperature was the most damaging influence to which the continuously reinforced concrete pavement was subjected.
7. The concrete pavement was subjected to extreme temperature changes during its early life.
8. On numerous occasions the curing compound was not applied until a few hours after the finishing operation. If concrete were allowed to cure until it gained sufficient strength before being subjected to extreme temperature changes, a more satisfactory bond would have formed between the concrete and the reinforcing steel, resulting in a more ideal crack pattern.
9. Reinforcing steel having a higher yield point strain should give better service.
10. It appears from the data that additional reinforcement is required in the intrados lane of the curve. This additional steel should be carried some distance along the tangent of each end of the curve.

11. The reinforcing steel spanning the crack yielded in tension due to temperature drop varying from 50 to 75 degrees Fahrenheit (See Appendix D).

12. It is shown in Appendix E that in all section types a much higher percentage of reinforcing steel is required to cause temperature cracking of the pavement.

13. It has been mentioned previously that yielding of the reinforcement caused by extremely low temperature could be prevented by using a steel having a higher yield point. Or alternatively, yielding could be prevented if more reinforcement were used. No relationship exists between strain in the reinforcing steel and the steel percentages. However, there is an indication that relationship exists between area of steel used and the strain in the steel. (See table below and Patell.)

ection ype	Location	% Reinforcement	Area Reinforcement in In.^{2}	Strain in in. x 10^{-6} for Temp. drop of 80°F	Strain in in. x 10^{-6} for Temp. drop of 95°F
7-2	I	.784	15.8	2000	2360
7-2	II	.784	15.8	1980	2360
7-1	III	.706	14.2	2400	2880
6-1	VII	.715	12.3	3100	3700
6-2	VIII	.815	14.1	2780	3280

The trend lines of Plate 11 indicate that pavement design should be based on the total area of the steel if yielding of the steel is to be prevented at shrinkage cracks. The slab thickness does not affect this part of design.

It is seen from Plate 11 that if yielding were to be prevented for a temperature drop of 95°F., 16.8 square inches of steel should have been provided in each section type. Expressing this in percent of the cross-section area of the pavement, then 0.84% steel is required in a 7 inch slab and 0.98% steel is required in a 6 inch slab.

X. SUMMARY OF CONCLUSIONS

1. Location I - Section Type B7-2 (7 inch slab, 0.784% Steel)

The loss of bond between the reinforcing bars and the concrete extended to a point about 16 bar diameters from the instigated crack when the strain in the reinforcing steel was in the elastic range. Additional bond loss took place after the reinforcing bars yielded in tension.

Reinforcing steel yielded in tension when the slab temperature dropped to -20°F. At this low temperature, the width of the instigated crack opened to 1/16th of an inch. An additional drop in temperature resulted in the crack opening to about 1/8th of an inch and the reinforcing bars spanning the crack strained to 8,000 micro inches/inch.

The use of a reinforcing steel having a yield point strain of 2,100 micro inches/inch would have prevented yielding of the steel bars at the cracks. As a result, the existing cracks would have not opened to such objectionable widths but more new cracks would probably have developed.

Linear relationships existed within the elastic range of steel between strains in the reinforcing bars and slab temperature, strain and width of the crack, and width of the crack and temperature after the pavement was about four weeks old.

2. Location II - Section Type B7-2 (7 inch slab, 0.784% steel)

The loss of bond between the concrete and the reinforcing bars extended to a point about 27 bar diameters from the instigated crack when the strain in the reinforcing bars

remained in the elastic range. After the bars yielded in tension additional loss of bond occurred. The reinforcing steel at the instigated crack started to yield at a slab temperature of about -10°F., at which temperature width of the instigated crack probably opened to 1/16th of an inch. When the temperature dropped to a low of -25°F. reinforcing bars at the crack strained far beyond the yield point of the steel and the width of the instigated crack exceeded 1/8th of an inch.

If a reinforcing steel having a yield point strain of 2,200 micro inches/inch had been used, no yielding would have taken place at a low in temperature of -25°F., and the width of the instigated crack would have remained within 1/11th of an inch.

A linear relationship existed within the elastic range of steel between strain in the reinforcing steel and slab temperature, strain and width of the crack, width of the crack and temperature after the pavement was about two weeks old.

3. Location III - Section Type B7-1 (7 inch slab, 0.706% steel)

The loss of bond between the concrete and the steel bars extended to a point about 24 bar diameters from the induced plane of weakness. No additional loss of bond occurred after the reinforcing bars at the crack yielded in tension.

The reinforcing steel at the instigated crack yielded in tension when the slab temperature dropped to about -15°F. At this low temperature the width of the instigated crack reached 1/32 of an inch. When the slab temperature dropped

to about -25°F., the reinforcing steel strained far beyond the yield point and the width of the crack increased probably to 1/16th of an inch.

The shrinkage crack which developed in the vicinity of the instigated crack had a considerable effect on the crack width opening at the induced plane of weakness.

No yielding of the reinforcing bars would have taken place at the instigated crack at -25°F. temperature if a reinforcing steel having a yield point strain of 2,300 micro inches/inch had been used.

4. Location IV - Section Type B6-1 (6 inch slab, 0.715% steel)

The lack of sufficient information, the development of a shrinkage crack close to the plane of weakness, coupled with a strange strain history at the instigated crack, does not permit the drawing of any definite conclusions at this time.

The reinforcing bars started to yield at the south edge of the pavement before the 51-day measurements were taken during which time a low of -13°F. had been recorded at the Calgary airport. There is some evidence of bending in the horizontal plane.

5. Location V - Section Type B6-1 (6 inch slab, 0.715% steel)

As at Location IV, only limited information is available. The data that are available indicate that reinforcing steel spanning the crack yielded in tension before the pavement was 50 days old. Some indications of bending action is also present at this location.

6. Location VI - Section Type B6-1 (6 inch slab, 0.715% steel)

The gaged panel at Location VI was subjected to bending action when the reinforcing bars at the crack strained elastically. The reinforcing bars spanning the instigated crack started to yield before the pavement was 42 days old, during which time a low of -13°F. had been recorded at the Calgary airport.

7. Location VII - Section Type B6-1 (6 inch slab, 0.715% steel)

The reinforcing bars spanning the crack started to yield before the pavement was fifty days old. It is probable that the reinforcing steel began to yield within thirty-one days after construction during which time a low of -5°F. was recorded at the Calgary airport. The yield point strain of the reinforcing bars was probably reached when the slab temperature dropped to 5°F. and the width of the crack opened to about 1/20 of an inch.

The reinforcing steel yielded in tension past the range of "SR-4" bakelite type gages when the pavement was subjected to an extremely low temperature and the instigated crack opened to a width exceeding 1/8 of an inch.

If a reinforcing steel having a yield point strain of 3,100 micro inches/inch had been used, no yielding would have taken place at the cracks, additional cracks would have probably developed and the existing cracks would not have opened to such objectionable widths.

8. Location VIII - Section Type B6-2 (6 inch slab, 0.815% steel)

The loss of bond between the concrete and the reinforcing bars extended to a point 16 bar diameters from the

instigated crack when the strain in the reinforcing steel remained within the elastic range. After the reinforcing bars spanning the crack strained past the yield point, the loss of bond increased to a point 24 bars diameters from the crack.

The reinforcing steel spanning the crack started to yield when the slab temperature dropped to about -5°F. and the instigated crack opened to 1/25 of an inch.

When the pavement was subjected to extremely low temperatures, the reinforcing bars strained past the range of the "SR-4" bakelite-type gages and the instigated crack opened to width exceeding 1/10 of an inch.

If a reinforcing steel having a yield point strain of 2,700 micro inches/inch had been used, no yielding would have taken place at the instigated crack at the slab temperature of -25°F., and the crack would have opened to 1/20 of an inch, unless additional cracks were developed.

9. Location IX - Section B6-2 (6 inch slab, 0.815% steel)

The reinforcing steel at the instigated crack strained within its elastic limit. The strain in the reinforcing bars reached 1,900 micro inches/inch when the slab temperature dropped to about -25°F. and the width of the instigated crack at this low temperature probably increased to 0.043 inches.

The loss of bond extended to a point about 20 bar diameters from the crack.

The strain in the reinforcing steel and width of the instigated crack increased at a decreasing rate for a given drop

in slab temperature.

The shrinkage crack which developed several inches east of the induced crack had a measurable effect on the strain pattern in the reinforcing bars located in the south lane of the pavement. At extremely low temperatures, the strain in the reinforcing steel distributed itself more evenly along the instigated crack, and the shrinkage crack east of the induced plane of weakness became inactive.

The length of the actively moving end extended some distance west of the test section from the expansion dam constructed at the east end of the continuously reinforced concrete pavement.

XI. RECOMMENDATIONS

In the course of strain measurements it was found that the "SR-4" strain indicator responded "sluggishly" to any change in strain. No explanation was available for this strange phenomenon for some time.

Experiments that were conducted at the University of Alberta revealed that when a capacitor was introduced into the electrical circuit, the "SR-4" strain indicator responded to change in strain in a similar manner as at the test site. Further investigation revealed that capacitance in the Wheatstone Bridge Circuit affects the initial reading only, and does not influence the change in strain. When a capacitor of 220 u u f was introduced into an electrical circuit the initial strain reading on the gage was changed by 100 micro inches/inch, a capacitor of 10,000 u u f changed the reading by 200 micro inches/inch. By immersing 40 feet of lead wire in a pail of water it was found that a capacitance of 12,000 u u f was developed. Therefore, the extreme conditions to which the lead wire might be subjected under the pavement would be a change in capacitance from 0 to 12,000 u u f, resulting in a maximum error of 200 micro inches/inch in strain measurements.

In view of the fact that moisture in the granular base may vary considerably, particularly below the crack in the pavement, it is felt that for the best results lead wires connecting the strain gages to the terminal box should be housed in a watertight conduit.

Terminal boxes buried in the ground had given very poor service. It is suggested that in future the terminal boxes be installed above the ground surface.

Initial strain measurements should be made before placing of concrete or after the initial set of concrete. On occasions, readings taken immediately after the finishing operation have given ridiculous results.

If at all possible, measurements should be taken every few hours throughout the day and night for the first few days after placing of concrete so that initial behaviour of the pavement could be determined.

Useful information may be gained by making a complete observation of crack widths at selected locations other than at the test panel.

Copper-constantan type temperature transducers were used to measure slab temperature at selected positions. Using this type of temperature gage it was necessary to measure cold junction temperature and the e.m.f. produced. The cold junction temperature was measured using an ordinary mercury thermometer and the e.m.f. was measured using a potentiometer. It was found that this method of securing temperature records was not very accurate and was time-consuming. Due to the difficulties encountered in measuring the cold junction temperature and reading the potentiometer, particularly in the winter season, it is suggested that in future projects of this type temperature sensitive resistance-wire measuring device be used.

This type of gage was designed and used successfully by the Continuous Pavement Research Group at the Lehigh University.

Full details of its construction as presented in the unpublished report "Continuously Reinforced Concrete Pavement Research" written by Continuous Pavement Research Group, Fritz Engineering Laboratory, Lehigh University for the American Iron and Steel Institute, are given in Appendix C.

BIBLIOGRAPHY

1. Teller, L. W., Sutherland, E.C., "The Structure Design of Concrete Pavements", Public Roads, Volume 17, 1936.

2. Schiffman, R. L., Taylor, I. J., Eney, W. J., "Continuously Reinforced Concrete Pavement Research in Pennsylvania", Lehigh University, Fritz Laboratory Report 252.1, January, 1957.

3. "Continuously Reinforced Concrete Pavement Research", Unpublished report written for American Iron and Steel Institute by the Continuous Pavement Research Group, Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa.

4. Ellert, K., "Experimental Concrete Pavements in Alberta", unpublished thesis, University of Alberta, 1959.

5. Dobie, W. B., Isaac, P. C., "Electric Resistance Strain Gages", English University Press Limited, London.

6. Friberg, B. F., "Frictional Resistance Under Contrete Pavements and Restraint Stresses in Long Reinforced Slabs", Proc. H.R.B., Vol. 33, pp. 167-182, 1954.

7. Yerlici, V. A., "Design of the Reinforcement in Continuously Reinforced Concrete Highway Pavements", Unpublished Report, Lehigh University.

8. McHenry, D., Walker, W. T., "Laboratory Measurements of Stress Distribution in Reinforcing Steel", Journal A. C., Volume 19, No. 10, June, 1948.

9. Monchor, F. L., Lissnor, H. R., Lipson, C. H., "Long-Time Electric Strain Gage Measurements on Concrete Reinforcing Rods at the Packard Proving Grounds Test Track", Proc. S.E.S.A., Volume IV, No. 1, 1948.

10. Sherlock, R. H., Belgin, Adil, "Protection of Electric Strain Gages in Concrete", Journal A. C., Nov. 1947, Proc. Volume 44.

APPENDIX A

APPLICATION AND WATERPROOFING OF ELECTRICAL STRAIN GAGES

APPENDIX A

APPLICATION AND WATERPROOFING OF ELECTRICAL STRAIN GAGES

(a) General Description

Basically there are two general types of Baldwin "SR-4" strain gages: (1) gages made on paper base which is impregnated with nitrocellulose; (2) gages molded in bakelite resins.

An electrical strain gage consists of a small grid of very fine wire which is either cemented to a paper base or bakelite resin base. Its principle of operation in measuring strain depends on the fact that the electrical resistance of the grid of wire varies directly as the strain the grid undergoes. If the gage is cemented firmly to a material, the fine wire grid will suffer the same strains as the material itself. By measuring the resistance changes of the grid by a sensitive galvonometer the actual strains in the material may be found. The strains are then converted to stresses by multiplying by the modulus of elasticity of the material.

The gages used in this project were "SR-4" made by Baldwin Southwank Locomotive Works, Philadelphia, U.S.A. The type of gages selected for this work were "AB-3" bakelite gages. The reason for selecting this type of gage was its proven stability under long time service in adverse climatic conditions and ability to withstand a moderate amount of abuse in installation and handling. A complete description of the method of applying those gages to steel surface is given by the makers in their bulletin No. 179, "The SR-4 Bonded Resistance Wire Strain Gauge", and need not be repeated here.

When properly attached, the strain gage grid is rigidly bonded to the steel (or other surface) and yet is electrically insulated from it. The gage will function satisfactorily as long as it remains completely dry. The principle cause of instability is moisture which is absorbed into the body of the gage. The effects of moisture are: (a) dimensional changes of bonding medium and cement which cause resistance changes due to resulting strains set up in gage filament; (b) changes of resistance due to conductivity caused by absorbed moisture. A secondary cause of instability is the long time aging of bonding medium and cement. The lower limit of the electrical resistance against this type of leakage is 50 megohms between grid and bar for absolutely reliable results.

Several methods of waterproofing gages embedded in concrete have been developed by different investigators(8,9,10). In a paper to the A.C.I.(8), two investigators of the U.S. Bureau of Reclamation, Denver, have listed requirements for an ideal type of "SR-4" gage protection, and then have given detailed description of two methods which they have successfully used.

(b) Application of Gages to Reinforcing Bars

After the bar deformations were removed and the surface areas at the gage locations were polished to a very smooth surface, these areas were covered with friction tape and the bars were stored awaiting the shipment of strain gages.

Before application of strain gages, the surfaces at gage locations were polished once more and thoroughly cleaned with acetone. The gages were checked for resistance and the under side of the gages were cleaned with acetone before application of cement.

In applying the gages to bars of circular cross-section, some difficulty was experienced in holding the gage centreline truly parallel to the direction of stress after application of pressure by means of specially designed clamps.

Waterproofing of Gages

After application of heat curing process and subsequent cooling off, the waterproofing process may begin. The following list of steps contains minimum procedure necessary to obtain reasonably good results. Omission of any one of them may be sufficient cause to spoil a gage location.

(1) After the bars cool off, apply a coat of Gaco Primer which prevents any moisture from the atmosphere being absorbed by the gage. It prevents the clean surface of the bar from rusting and provides good bond between neoprene and the steel. A second coat of primer should be applied about one hour before application of neoprene.

(2) Test the leakage resistance and true resistance of the applied gage. Use a maximum test voltage of 45 volts to measure leakage resistance, and a wheatstone bridge to measure true resistance. A leakage resistance of less than 50 megohms and a true resistance varying by more than 1.0 ohms from the listed resistance indicates that the gage is of doubtful usefulness and should be replaced.

(3) Clean all excess Duco cement from the bar surrounding the gage.

(4) Bend the lead out wires of the gage back over the gage. The lead out wires must be insulated from the steel surface.

(5) Solder the insulated lead wires to the gage leads. The insulation of these wires should be cut back by no more than ½ inch. Soldered connections should be smooth. Sharp projections must be avoided. The insulated lead wires may be either the single-strand or multi-strand type; single-stand wire is preferred. The insulation itself must be high quality rubber or plastic insulation. Lacquered fibre insulation is not acceptable.

(6) To prevent damage to the gages by pulling on the leads tie the leads to the bar with fibreglass tape.

(7) Apply four to six coats of neoprene. Each coat should be allowed to dry thoroughly before application of successive coats. After application of the last coat, apply the heat curing process for at least 12 hours at a temperature of 175°F.

(8) Apply a coat of petrolastic asphalt and apply heat until the surface is perfectly smooth and free from air pockets.

(9) Apply a layer of electrician tape over the layer of petrolastic asphalt. Petrolastic asphalt in room temperature becomes sticky; a coat of electrician's tape provides clean handling of bars.

(d) Discussion of Method

The method as described above is rather slow and time consuming, especially if only several gages can be waterproofed at one time. However, if many gages can be waterproofed at one time, the time is well spent.

This method is especially suited for field installations and should be excellent for laboratory investigations, especially if a large number of gage installations is contemplated.

After six months of service a large majority of gages have given good service.

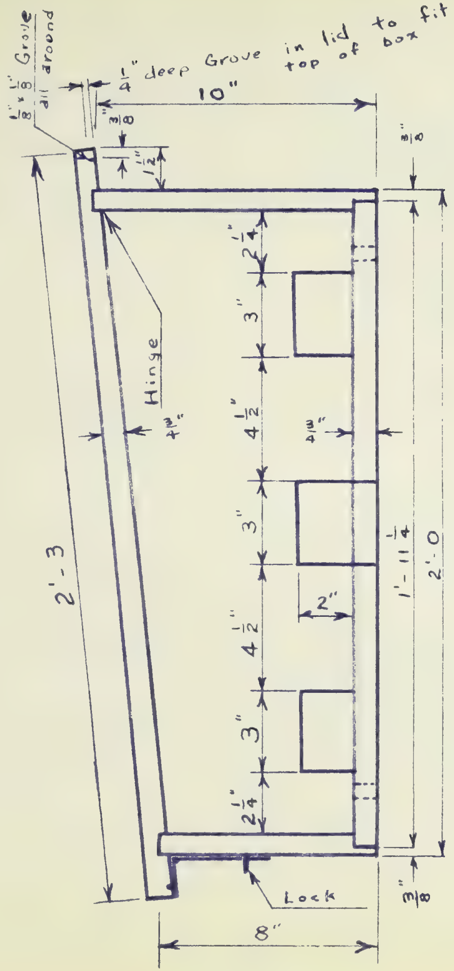
As mentioned before, other methods of waterproofing have been developed. The U.S. Bureau of Reclamation, Denver, describe two methods. In the first method 3M - Adhesive, which is air-setting rubber cement, is used with Tygonite N-15-B cement. The second method described by the Bureau of Reclamation involves vulcanizing a neoprene rubber housing over the gage to the steel bar.

Another method is described in a paper in the S.E.S.A. Proceedings(9). The procedure is somewhat similar to the Tygonite Method, but Petrosene B Wax is used as the chief waterproofing agent. Long-term leakage resistance is claimed in a field test.

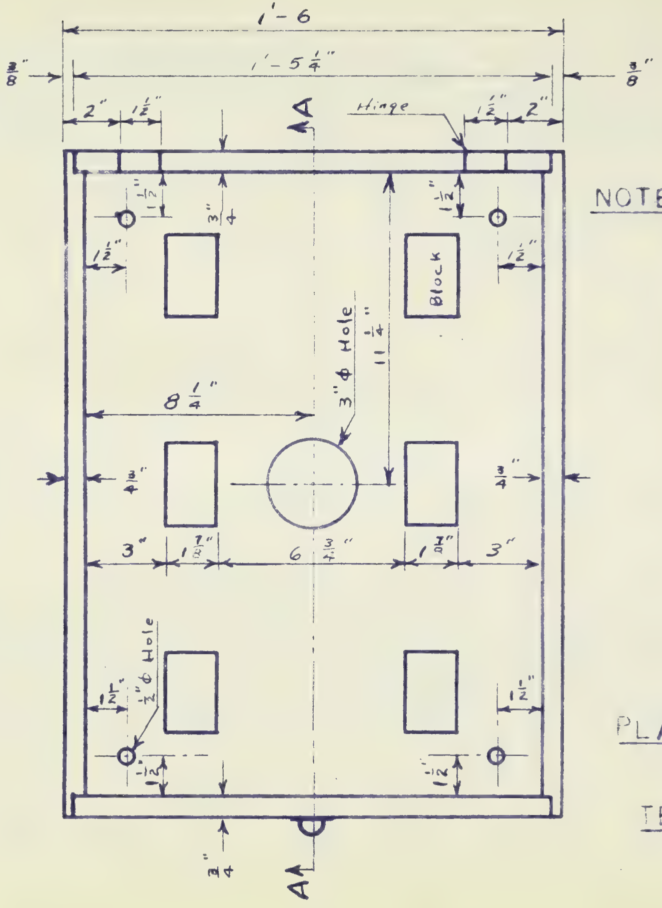
The results of all long-term tests are at present rather doubtful because of the tendency of the Duco Cement holding the gage to the steel to creep. This, of course, causes an extra strain in the gage not undergone by the material, causing resistance change readings to be not truly representative of strains in the test material.

APPENDIX B

MISCELLANEOUS DIAGRAMS AND CURVES



SECTION A-A

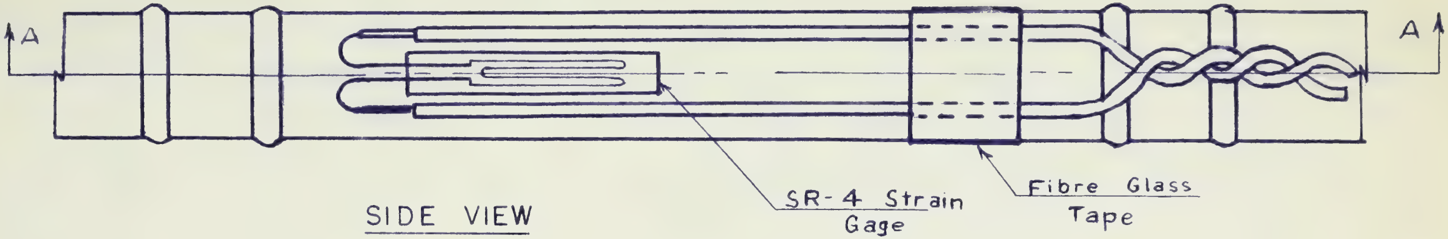


PLAN VIEW OF BOTTOM

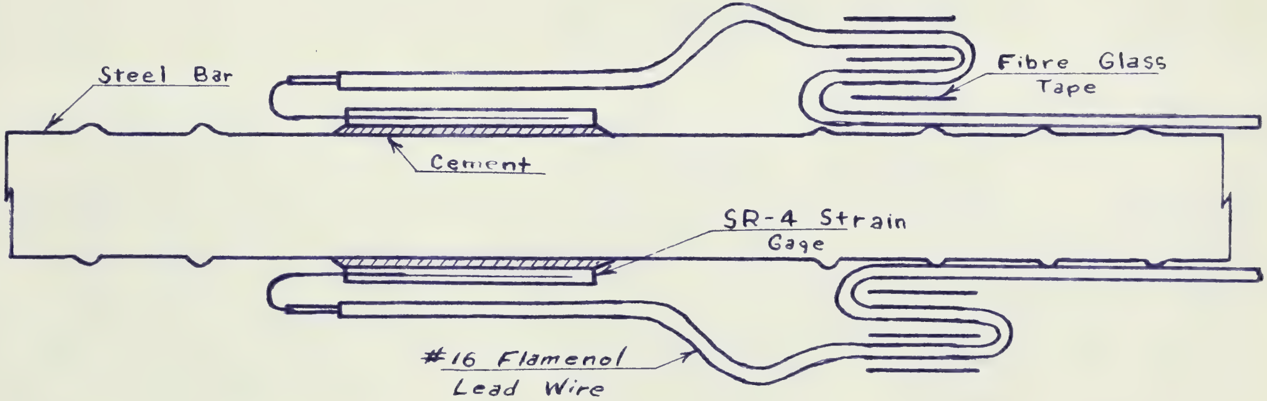
NOTE Box is made of
3/4" plywood.
Cover is 1'-9 wide

PLATE 1

TERMINAL BOX



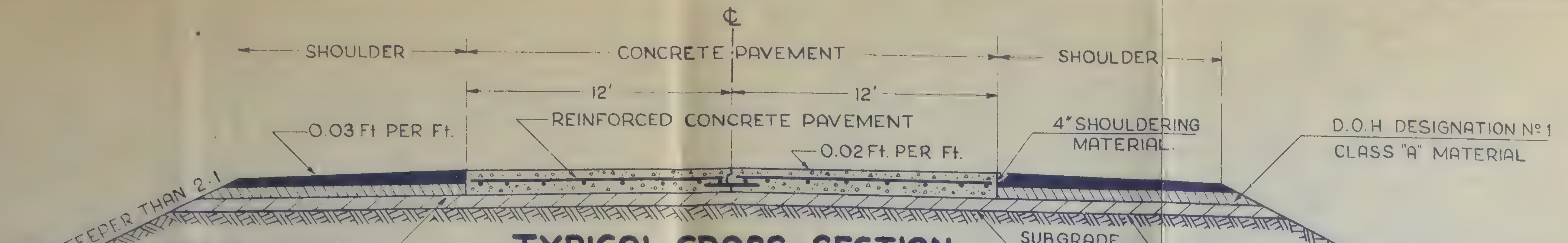
SIDE VIEW



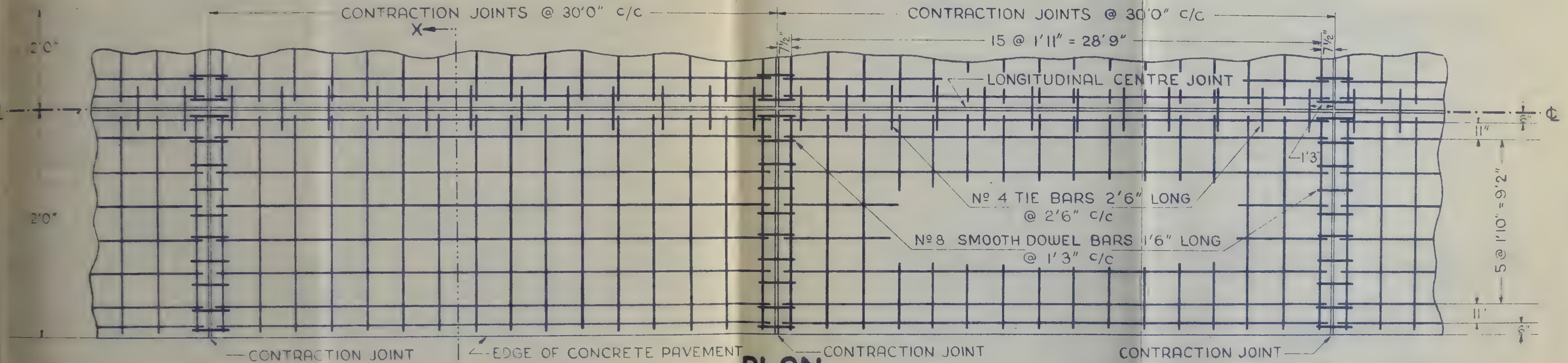
SECTION A-A

PLATE 2

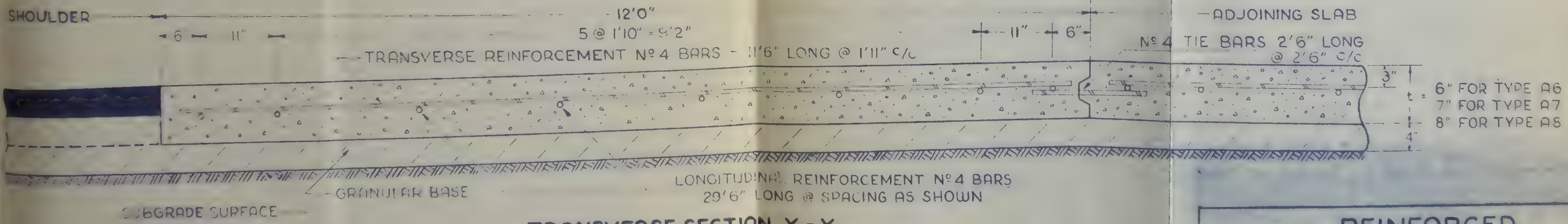
ATTACHMENT of SR-4 STRAIN GAGES to STEEL REINFORCING BAR



TYPICAL CROSS-SECTION
FOR TYPE "A" REINFORCED CONCRETE PAVEMENT WITH ASPHALTIC BOUND SHOULDERS



PLAN
TYPICAL REINFORCED SLAB TYPE "A"



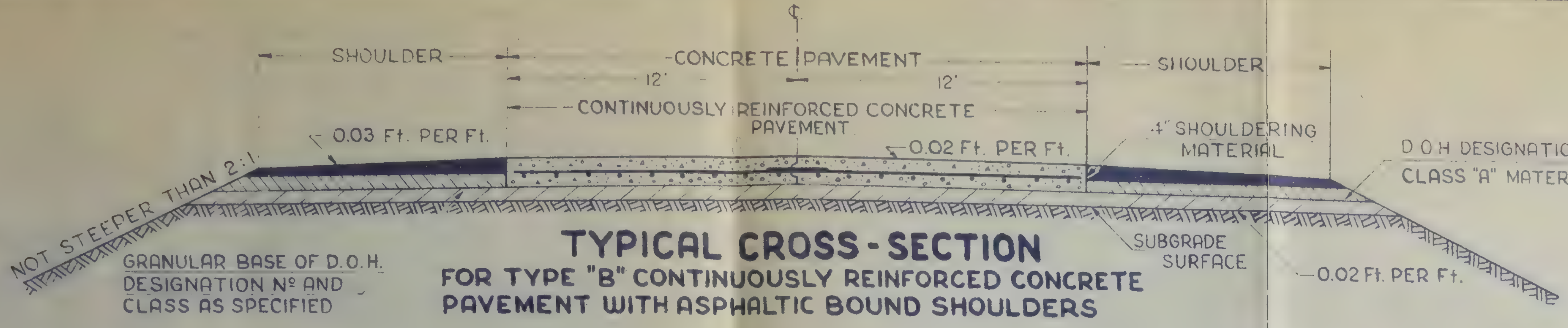
TRANSVERSE SECTION X - X

NOTE: LONGITUDINAL AND TRANSVERSE REINFORCING SHALL BE DEFORMED BARS OF HARD GRADE STEEL. DOWELS SHALL BE SMOOTH BARS OF HARD GRADE STEEL. TIE BARS SHALL BE DEFORMED BARS OF INTERMEDIATE OR STRUCTURAL GRADE STEEL.

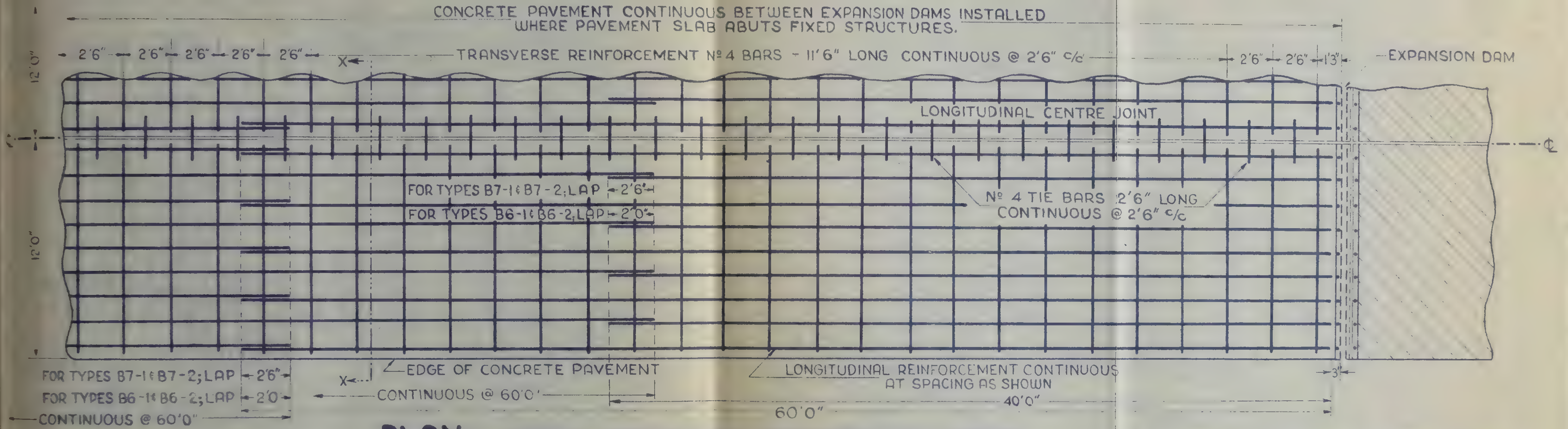
FOR REINFORCED CONCRETE PAVEMENT TYPE A6 t = 6 INCHES, TYPE A7 t = 7 INCHES AND TYPE A8 t = 8 INCHES. SPACING AND SIZE OF LONGITUDINAL AND TRANSVERSE REINFORCING STEEL AS DETAILED SHALL BE THE SAME FOR TYPES A6, A7 AND A8 REINFORCED CONCRETE PAVEMENTS.

REINFORCED
CONCRETE PAVEMENT
TYPE "A"
2 LANES WITH
ASPHALTIC BOUND SHOULDERS

PLATE 3



TYPICAL CROSS-SECTION
FOR TYPE "B" CONTINUOUSLY REINFORCED CONCRETE PAVEMENT WITH ASPHALTIC BOUND SHOULDERS

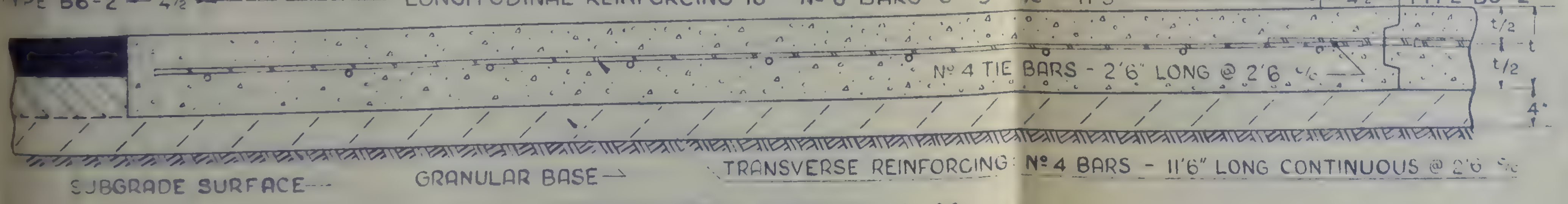

CONCRETE PAVEMENT CONTINUOUS BETWEEN EXPANSION DAMS INSTALLED WHERE PAVEMENT SLAB ABUTS FIXED STRUCTURES.
2'6" 2'6" 2'6" 2'6" 2'6"
X
TRANSVERSE REINFORCEMENT Nº 4 BARS - 11'6" LONG CONTINUOUS @ 2'6" c/c
2'6" 2'6" 1'3"
EXPANSION DAM
12'0"
12'0"
℄
LONGITUDINAL CENTRE JOINT
FOR TYPES B7-1 & B7-2; LAP 2'6"
FOR TYPES B6-1 & B6-2; LAP 2'0"
Nº 4 TIE BARS 2'6" LONG CONTINUOUS @ 2'6" c/c
FOR TYPES B7-1 & B7-2; LAP 2'6"
FOR TYPES B6-1 & B6-2; LAP 2'0"
CONTINUOUS @ 60'0"
X
EDGE OF CONCRETE PAVEMENT
CONTINUOUS @ 60'0"
LONGITUDINAL REINFORCEMENT CONTINUOUS AT SPACING AS SHOWN
60'0"
40'0"
3"

PLAN - TYPICAL CONTINUOUSLY REINFORCED SLAB TYPE "B"

NOTE: FOR TYPES B7-1 & B7-2 CONTINUOUSLY REINFORCED CONCRETE PAVEMENT: t = 7 inches
FOR TYPES B6-1 & B6-2 CONTINUOUSLY REINFORCED CONCRETE PAVEMENT: t = 6 inches

SHOULDER — 12'0" — ADJOINING SLAB

TYPE B7-1	8"	LONGITUDINAL REINFORCING 9 - Nº 8 BARS @ 1'4" c/c = 10'8"	8"	TYPE B7-1
TYPE B7-2	4½"	LONGITUDINAL REINFORCING 10 - Nº 8 BARS @ 1'3" c/c = 11'3"	4½"	TYPE B7-2
TYPE B6-1	7"	LONGITUDINAL REINFORCING 14 - Nº 6 BARS @ 10" c/c = 11'3"	7"	TYPE B6-1
TYPE B6-2	4½"	LONGITUDINAL REINFORCING 16 - Nº 6 BARS @ 9" c/c = 11'3"	4½"	TYPE B6-2


Nº 4 TIE BARS - 2'6" LONG @ 2'6" c/c
t/2
t
t/2
4"
SUBGRADE SURFACE
GRANULAR BASE
TRANSVERSE REINFORCING Nº 4 BARS - 11'6" LONG CONTINUOUS @ 2'6" c/c

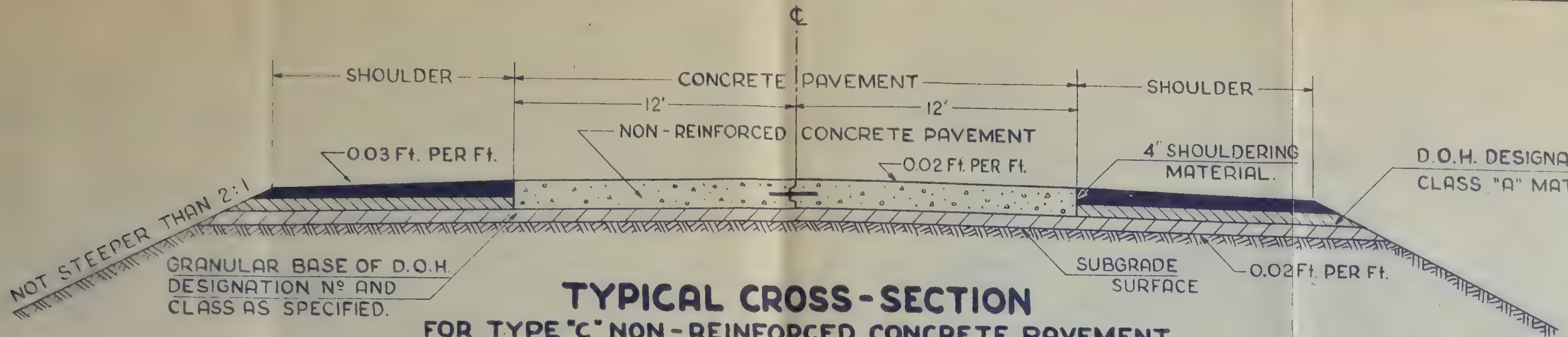
TRANSVERSE SECTION X - X

NOTE: LONGITUDINAL AND TRANSVERSE REINFORCING SHALL BE DEFORMED BARS OF HARD GRADE STEEL. TIE BARS SHALL BE DEFORMED BARS OF INTERMEDIATE OR STRUCTURAL GRADE STEEL.

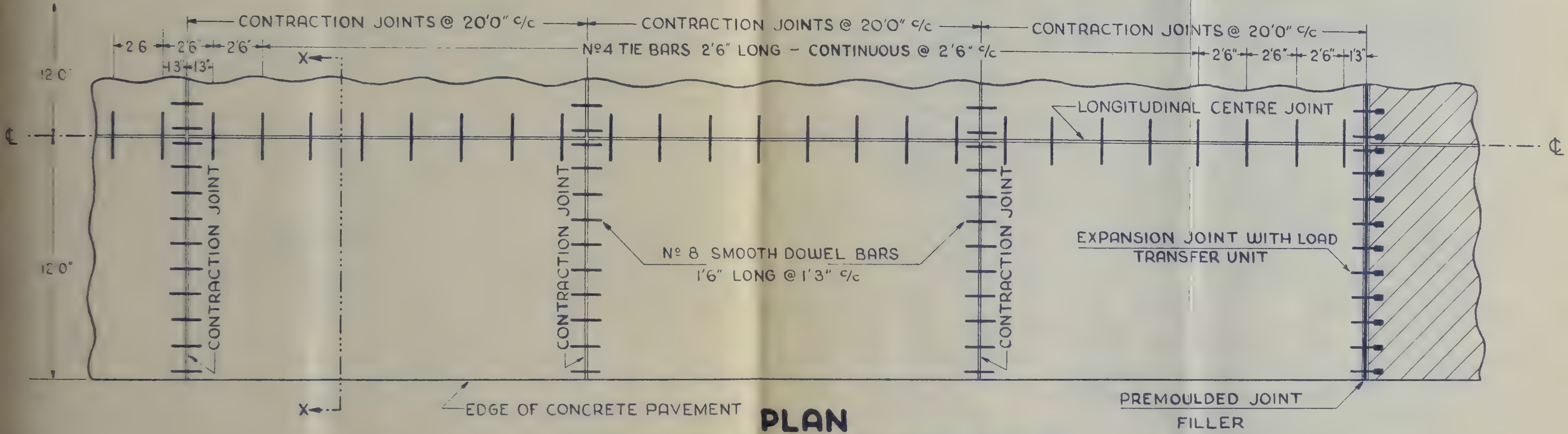
SPACING AND SIZE OF TRANSVERSE REINFORCING STEEL SHALL BE THE SAME FOR TYPES B7-1, B7-2, B6-1 AND B6-2 CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS. SPACING AND SIZE OF LONGITUDINAL REINFORCING SHALL BE AS SHOWN ABOVE.

CONTINUOUSLY REINFORCED
CONCRETE PAVEMENT
TYPE "B"
2 LANES WITH
ASPHALTIC BOUND SHOULDERS

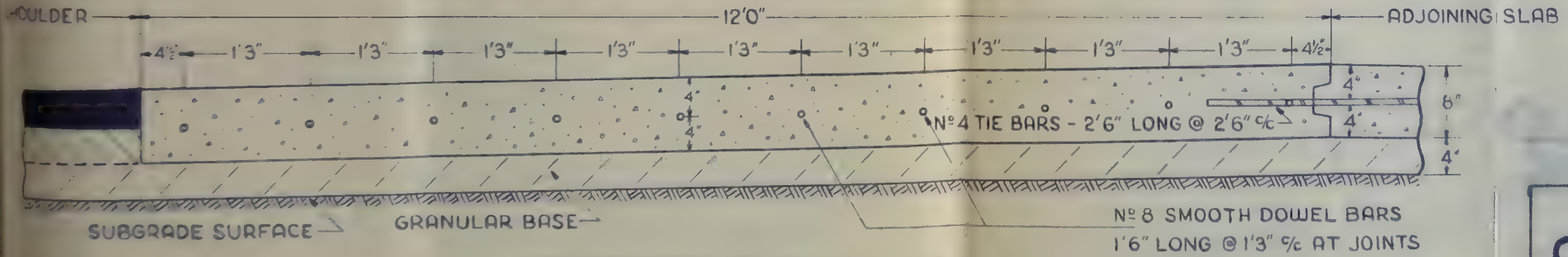
PLATE 4



TYPICAL CROSS-SECTION
FOR TYPE "C" NON - REINFORCED CONCRETE PAVEMENT
WITH ASPHALTIC BOUND SHOULDERS


CONTRACTION JOINTS @ 20'0" c/c
CONTRACTION JOINTS @ 20'0" c/c
CONTRACTION JOINTS @ 20'0" c/c
2'6
2'6
2'6
1'3
1'3
X
Nº4 TIE BARS 2'6" LONG - CONTINUOUS @ 2'6" c/c
2'6"
2'6"
2'6"
1'3"
12'0"
12'0"
℄
℄
LONGITUDINAL CENTRE JOINT
CONTRACTION JOINT
CONTRACTION JOINT
CONTRACTION JOINT
Nº 8 SMOOTH DOWEL BARS 1'6" LONG @ 1'3" c/c
EXPANSION JOINT WITH LOAD TRANSFER UNIT
X
EDGE OF CONCRETE PAVEMENT
PREMOULDED JOINT FILLER

PLAN
TYPICAL NON - REINFORCED SLAB TYPE "C"



TRANSVERSE SECTION X - X

NOTE: TIE BARS SHALL BE DEFORMED BARS OF INTERMEDIATE OR STRUCTURAL GRADE STEEL.
DOWEL BARS SHALL BE SMOOTH BARS OF HARD GRADE STEEL.

NON - REINFORCED
CONCRETE PAVEMENT
TYPE "C"
2 LANES WITH
ASPHALTIC BOUND SHOULDERS

PLATE 5

CONCRETE PAVEMENT

WEST OF CALGARY—WEST OF BOWNESS

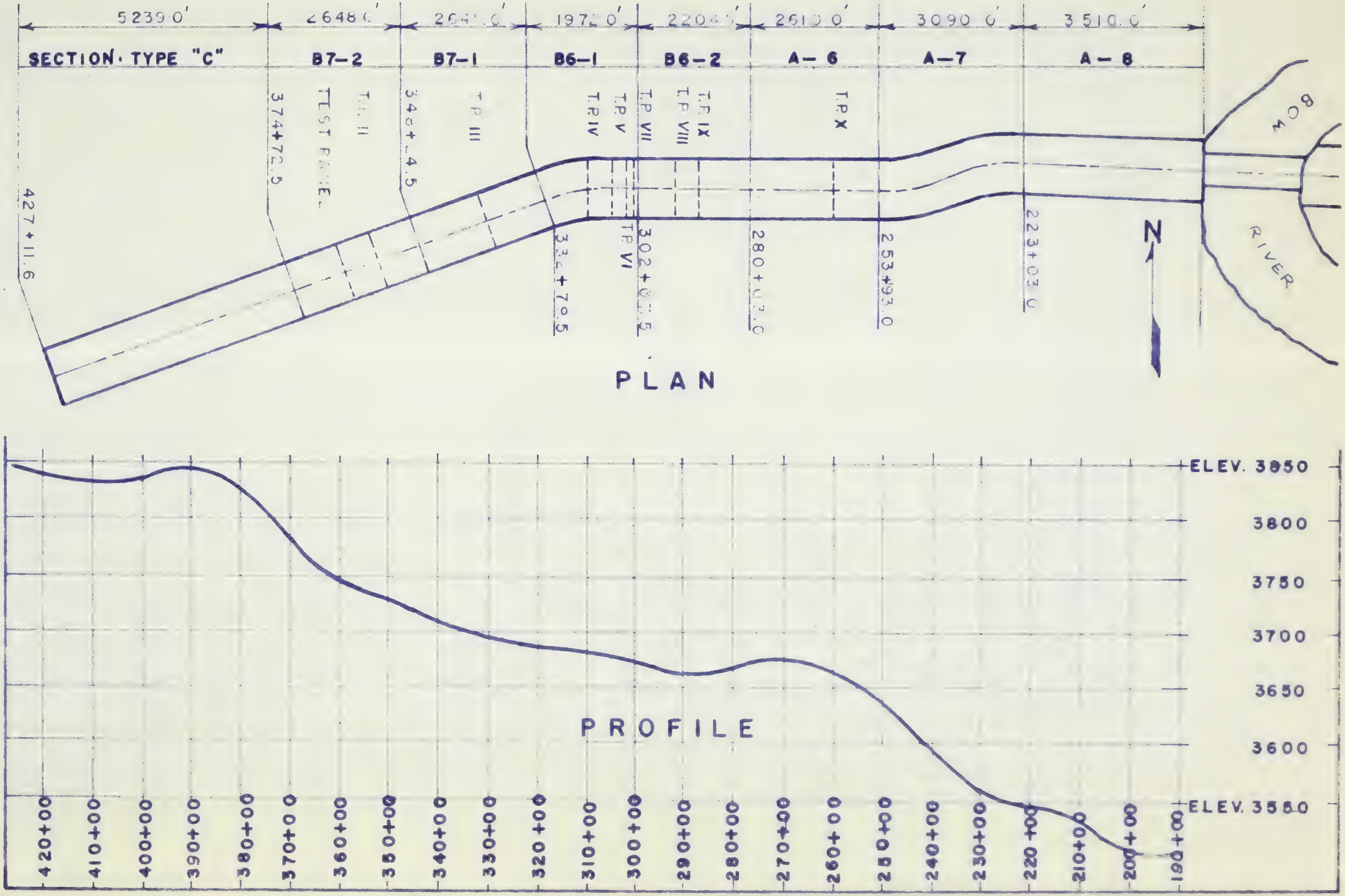
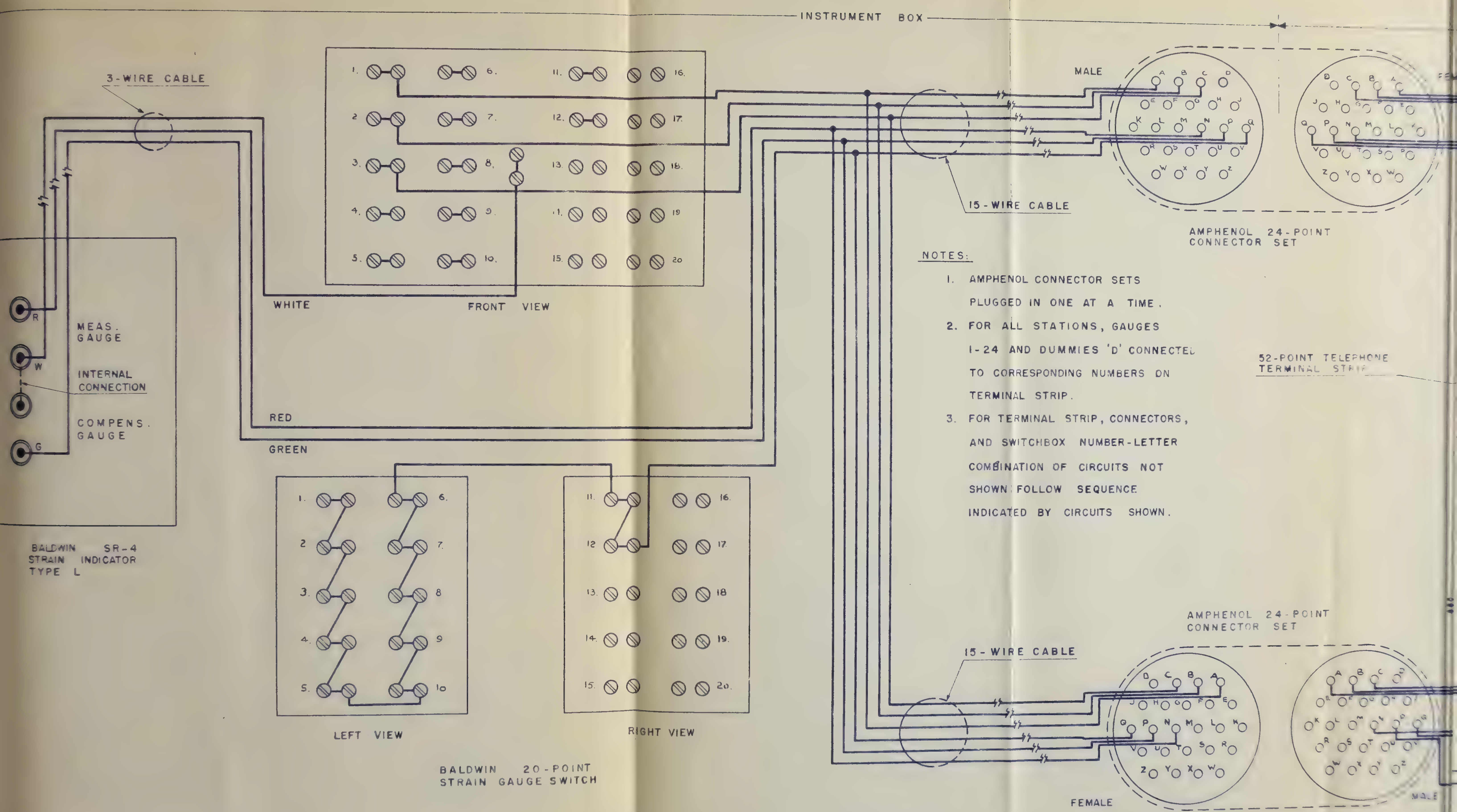
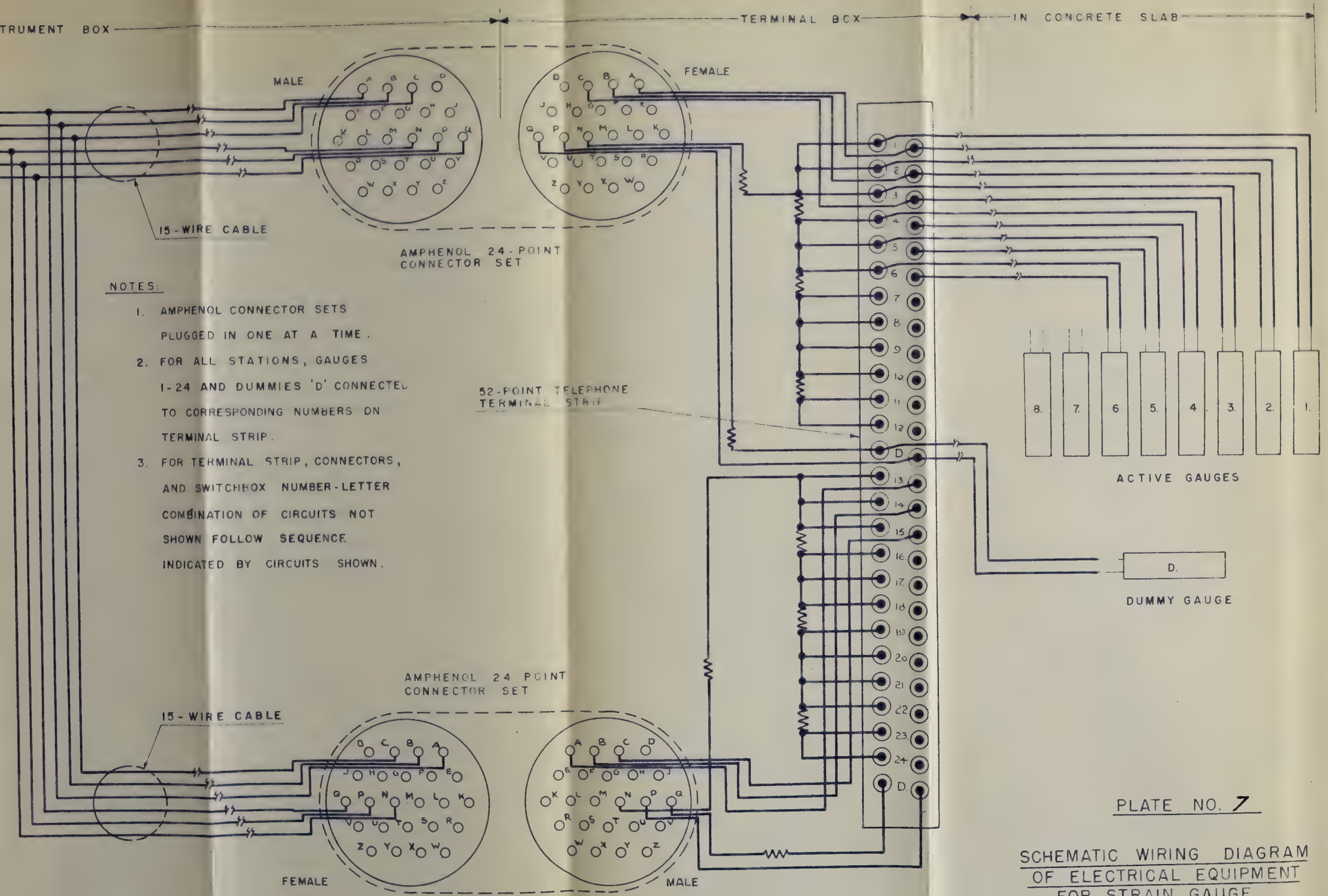


PLATE 6



NOTES:

1. AMPHENOL CONNECTOR SETS PLUGGED IN ONE AT A TIME.
2. FOR ALL STATIONS, GAUGES 1-24 AND DUMMIES 'D' CONNECTED TO CORRESPONDING NUMBERS ON TERMINAL STRIP.
3. FOR TERMINAL STRIP, CONNECTORS, AND SWITCHBOX NUMBER-LETTER COMBINATION OF CIRCUITS NOT SHOWN; FOLLOW SEQUENCE INDICATED BY CIRCUITS SHOWN.

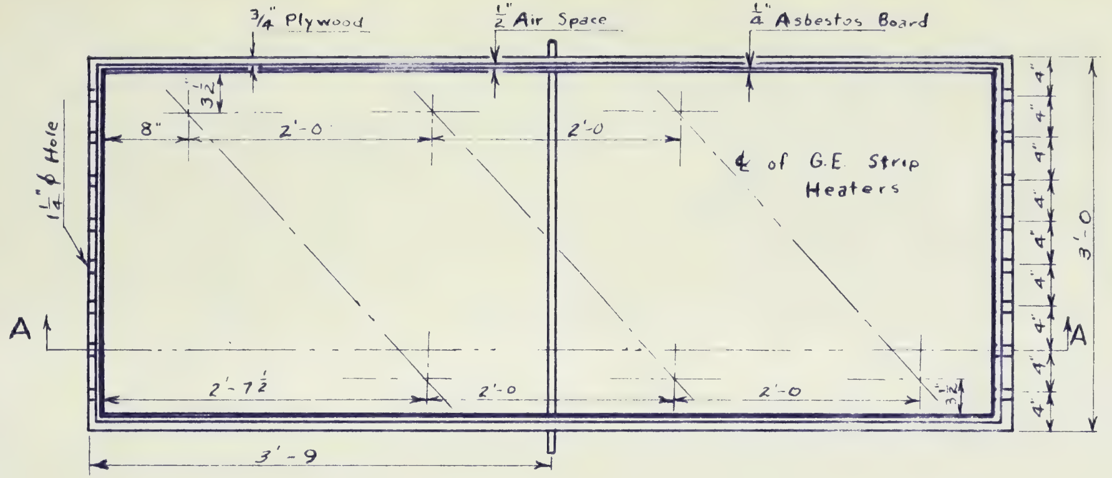


NOTES:

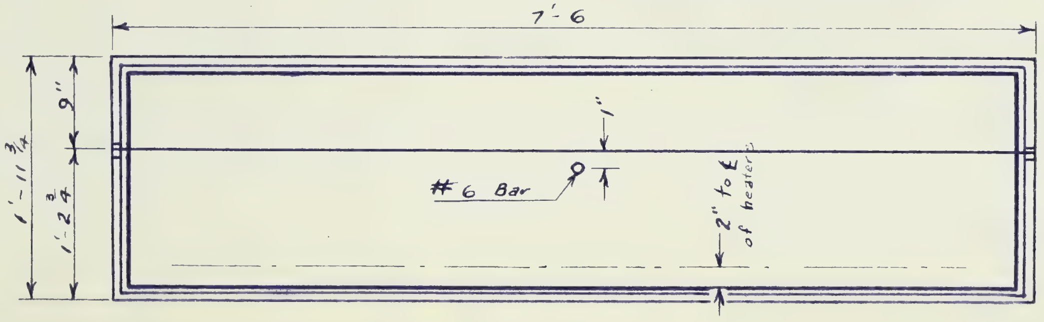
1. AMPHENOL CONNECTOR SETS PLUGGED IN ONE AT A TIME.
2. FOR ALL STATIONS, GAUGES 1-24 AND DUMMIES 'D' CONNECTED TO CORRESPONDING NUMBERS ON TERMINAL STRIP.
3. FOR TERMINAL STRIP, CONNECTORS, AND SWITCHBOX NUMBER-LETTER COMBINATION OF CIRCUITS NOT SHOWN FOLLOW SEQUENCE INDICATED BY CIRCUITS SHOWN.

PLATE NO. 7

SCHEMATIC WIRING DIAGRAM OF ELECTRICAL EQUIPMENT FOR STRAIN GAUGE INSTRUMENTATION.



PLAN VIEW of BOTTOM



SECTION A-A

PLATE 8

OVEN

REINFORCED CONCRETE TEST ROAD

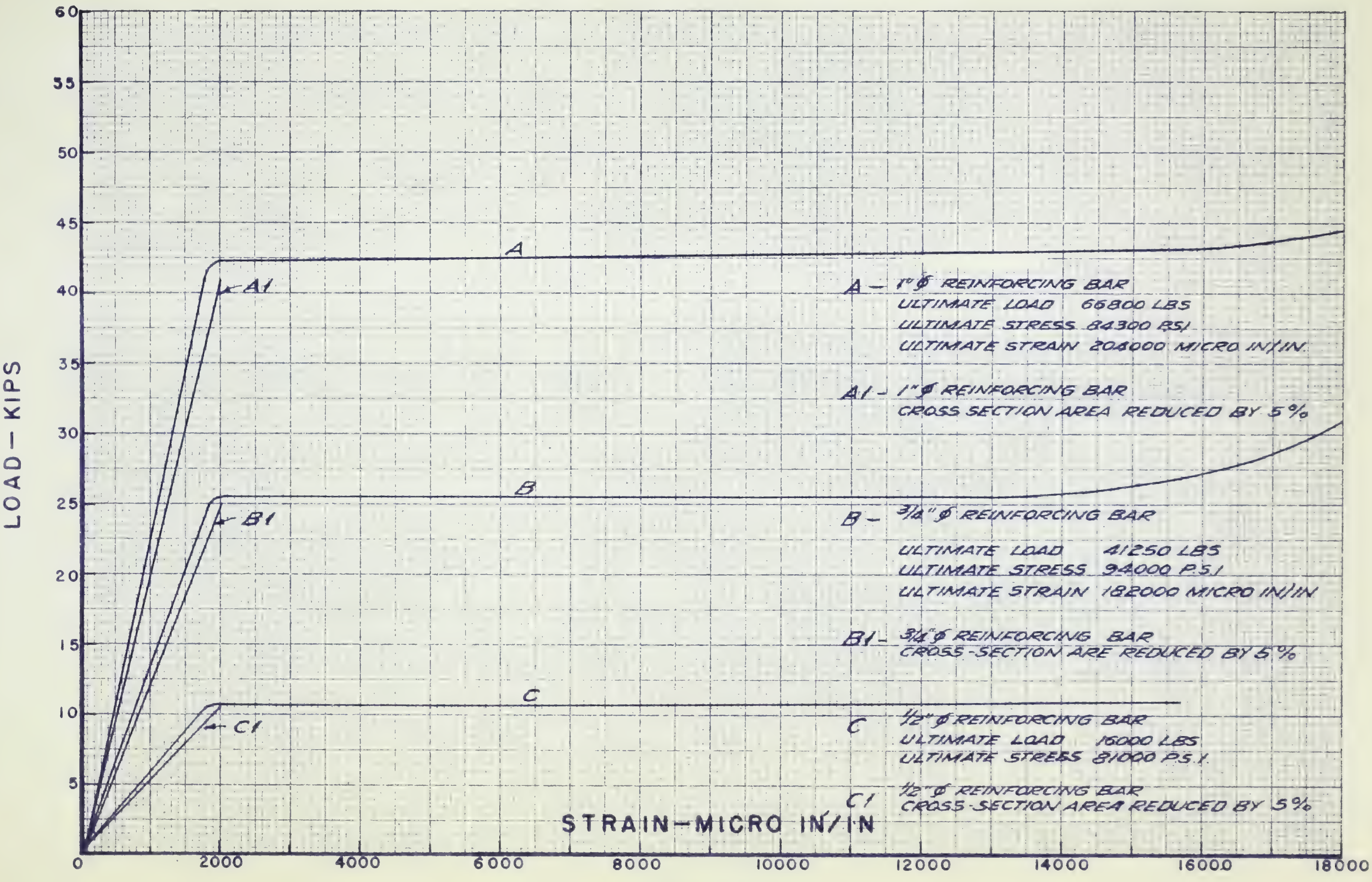


PLATE 9

CONTINUOUSLY REINFORCED PAVEMENT

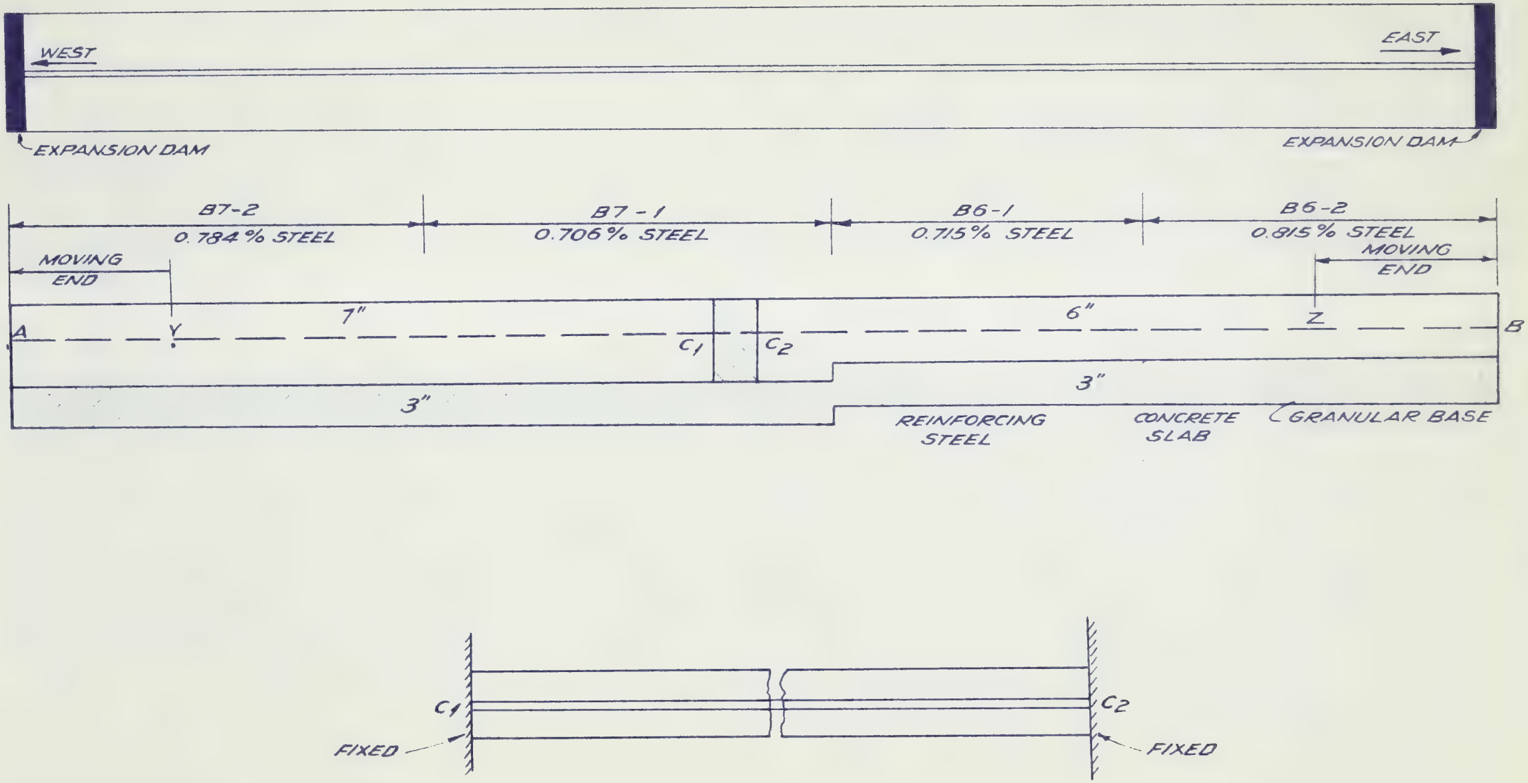


PLATE 10

STEEL AREA - STRAIN CURVE

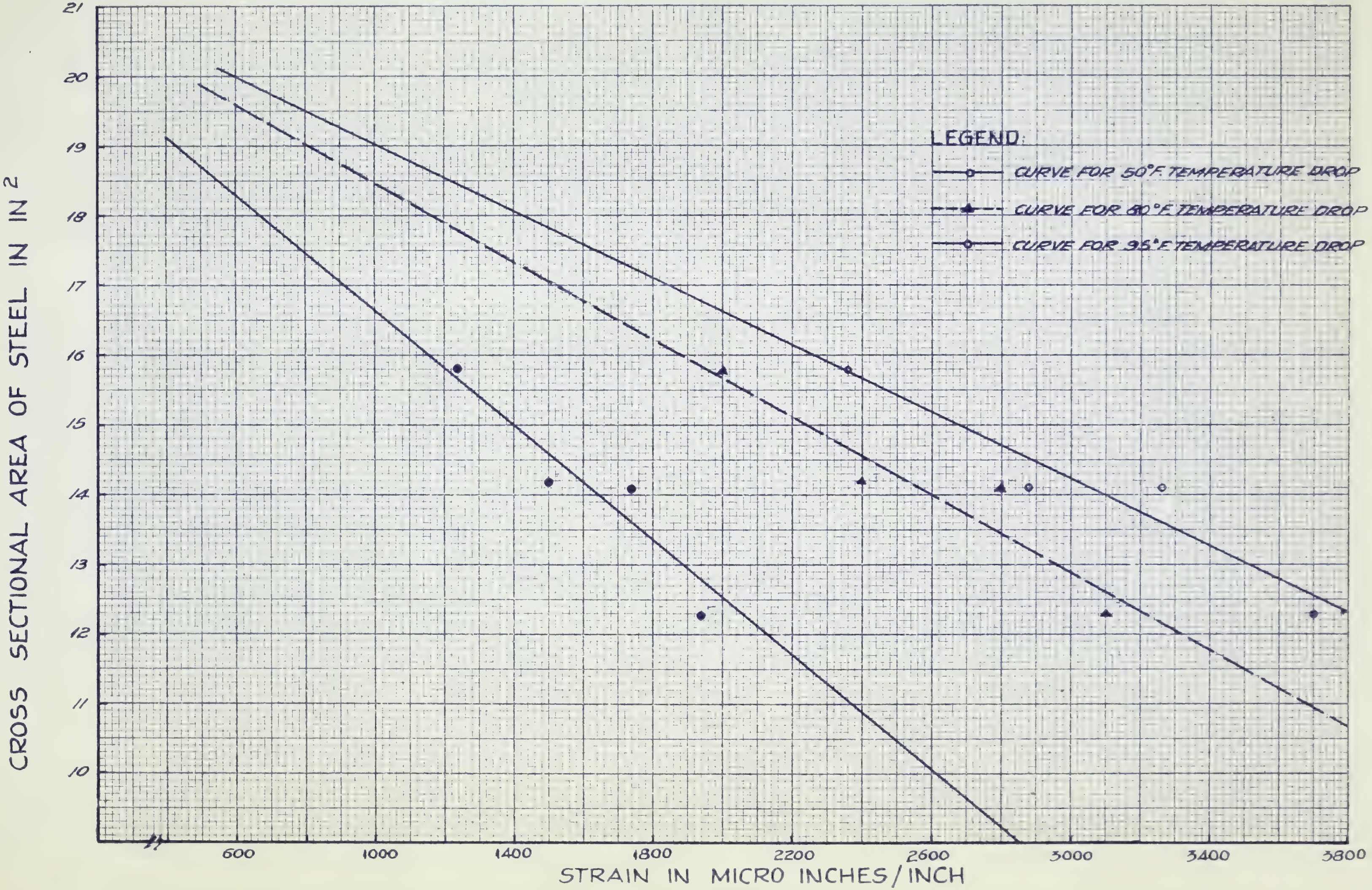
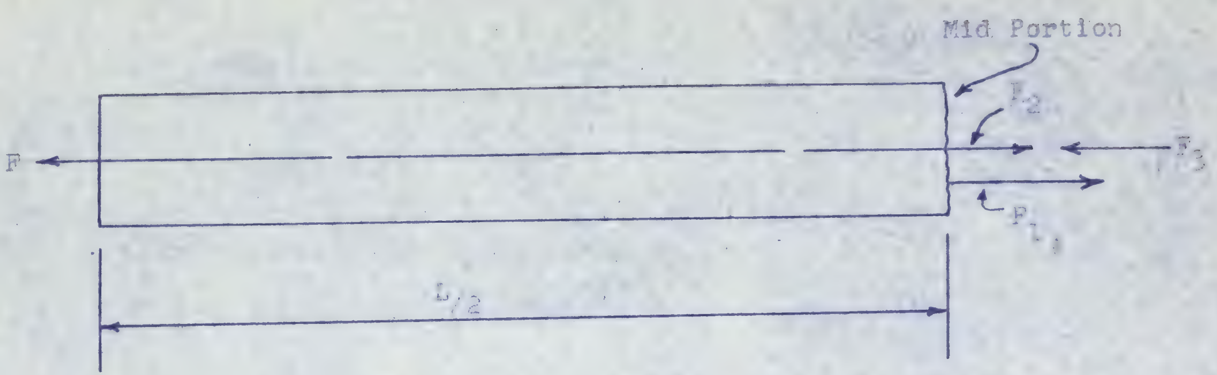


PLATE 11



F - Total tensile force which the steel carries at the crack

F_1 - Maximum tensile strength of concrete

F_2 - Tensile force developed in the steel

F_3 - Compressive force developed in the steel due to shrinkage of concrete

L - Length of uncracked slab

PLATE 12

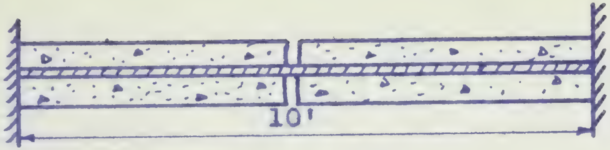


Fig. a

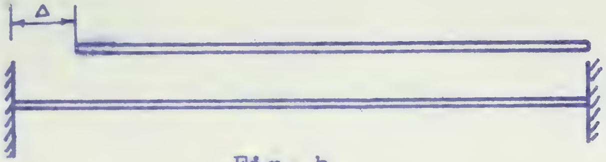


Fig. b

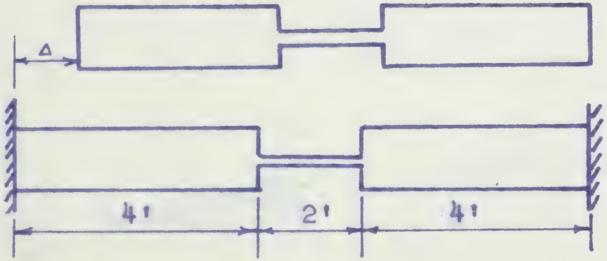
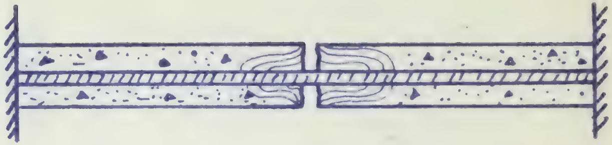


Fig. c



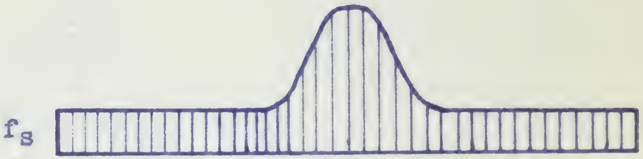


Fig. d

Stress in Reinforcing Steel

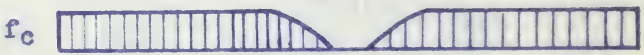


Fig. f

Stress in Concrete

Analysis of Reinforced Concrete Slab Fixed at Midpoints Between Cracks

PLATE 13

APPENDIX C

DESIGN AND CONSTRUCTION OF TEMPERATURE MEASURING GAGE

APPENDIX C

DESIGN AND CONSTRUCTION OF TEMPERATURE MEASURING GAGE

The temperature sensitive element consisted of approximately 33 inches of No. Forty, 99.8% nickel wire with Formvar insulation. This wire was cut to a length having a resistance of 17 ohms at a temperature of 70°F. A loop was formed in the wire and the free ends were soldered to standard two-conductor gage leads. Only 1/8 of an inch of insulation was removed from the ends of the wires, and with a small soldering iron it was possible to make a sound solder joint without melting the adjacent insulation.

The attached loop was then wrapped around the two gage leads approximately 1/4 of an inch back from their ends, and the end of the loop was held in place with a drop of plastic cement. The comparitive stiffness of the heavier gage lead wires prevented electrical shorting of the soldered ends until the water-proofing and protective coatings were applied to the gage.

The completed gage was only 3/16 of an inch in diameter and provided a means of obtaining temperature measurements at a precise location within the pavement structure.

In order to use these gages as an active arm of a 120 ohms-per-arm bridge circuit, it was necessary to add a fixed resistance of 103 ohms in series with 17 ohms provided by the temperature sensitive nickel wire.

The fixed resistors made with No. 34 cotton insulated Advance wire having a resistance of 7.52 ohms per foot. They were wound on fibre glass cores and given a protective coating

of insulating varnish. Several of these resistors were tested and found to have no significant sensitivity to temperature changes between 30°F. and 140°F. Since the nickel wire had a nominal temperature coefficient of resistance of 0.006, while at the Advance wire was only 0.0002, it seemed reasonable to assume that any change in the resistance of the 120-ohm circuit would be due to the temperature sensitivity of the nickel wire in the transducer.

Extreme care in the construction of these gages enabled the use of the same calibration factor with an entire lot of 70 gages and with less than 1% differential error within a temperature range of 0°F. and 120°F. When used with standard 120-ohm strain gage instruments, 175 micro inches/inch of indicated strain was equal to 1°F. change of temperature at the gage.

When an electric current flows in a circuit, heat is generated by the resistance of the conducting materials. With constant input voltage, the temperature of this material will rise until the dissipation of the heat by radiation or thermal conductivity is equal to the heat that is generated. It was found that this phenomenon caused a sudden rise in the indicated temperature from each of the gages as they were switched into the instrument circuit, but that after about 10 seconds, this "self-heating" stabilized and reliable measurements could be obtained.

All gages were calibrated at a known temperature after they were attached to the terminal board at the construction site. Before installation into the pavement, they were

submerged in an insulated water bath and checked with a laboratory mercury-column thermometer. The indicated resistance of the gage at this static temperature formed the basis for all subsequent measurements.

APPENDIX D

SAMPLE CALCULATIONS

APPENDIX D

SAMPLE CALCULATIONS

Notation

f_s - stress in reinforcing steel
E_s - modulus of elasticity of steel
E_c - modulus of elasticity of concrete
A_s - cross-sectional area of steel
A_c - cross-sectional area of concrete
A_T - transformer area
- coefficient of thermal expansion of steel and concrete
e - unit strain in inches/inch
T - temperature drop
L_1 - length of steel of area as producing the same deformation characteristics as the actual section between two fixed ends.
- total change in length in inches
n - modular ratio

Since only very small movements take place between the concrete slab and the base in the central portions of the continuously reinforced concrete pavement, and since these movements are confined to portions of the slab in the immediate vicinity of the cracks, it may be assumed that sections midway between the cracks are stationary or fixed (Fig. a, Plate 13).

It has been pointed out that the reinforcing steel in the continuously reinforced concrete pavement yielded in tension at the cracks for a given temperature drop. As will

be seen, had the steel not been embedded in concrete, the same temperature change would not have produced yielding. The reason for different behaviour for these two cases may be explained by considering them in detail.

1. Reinforcing steel bar 10 feet in length fixed at both ends (Fig. b, Plate 13).

Assume $= 6.5 \times 10^{-6}$ in./in./$^{\circ}$F.

$T = 100^{\circ}$F.

$E_s = 30 \times 10^{6}$ psi.

The unit strain in the steel due to 100°F. temperature drop

$e = 6.5 \times 10^{-6} \times 100$

$e = 6.5 \times 10^{-4}$

Therefore unit stress

$f_s = 30 \times 10^{6} \times 6.5 \times 10^{-4}$

$f_s = 19{,}500$ psi. which is much below the yield point stress of the reinforcing steel.

2. Reinforced concrete slab 10 feet in length fixed at both ends (Fig. a, Plate 13).

$$m = \frac{E_s}{E_c}$$

$$m = \frac{30 \times 10^{6}}{4.5 \times 10^{6}} = 6.7$$

considering Section Type B7-2

Transformed Area (Fig.c, Plate 13).

$$A_T = \frac{A_c}{n} + A_s$$

$$A_T = \frac{105}{6.5} + 0.795$$

$A_T = 17$ square inches.

Equivalent Length

$$L_1 = \frac{0.795}{17} \times 4 \times 12 \times 2 + 2 \times 12$$

$$L_1 = 28.5 \text{ inches.}$$

If the reinforced concrete slab were allowed to contract due to the temperature drop, the change in length due to 100°F. temperature drop would be

$$= 6.5 \times 10^{-6} \times 100 \times 120$$

$$= 0.072 \text{ inches.}$$

If sufficient force were applied to bring the slab to its original length, the unit strain in the steel at the crack

$$e = \frac{\quad}{L_1} = \frac{0.072}{28.5} = 0.00252 \text{ inches/inch}$$

and the stress in the steel at the crack

$$f_s = 30 \times 10^6 \times 2.52 \times 10^{-3}$$

$f_s = 75{,}000$ psi. which is above the yield point stress of the steel used.

Stress in the reinforcing steel reduces rapidly as the distance from the crack increases. The stress in the reinforcing steel remains constant at points where strain in concrete remains equal to the strain in the steel (Fig. d and Fig. f, Plate 13).

The above calculations indicate that almost all of the longitudinal deformation of the slab caused by the temperature drop takes place in the reinforcing steel at the crack.

APPENDIX E

SAMPLE CALCULATIONS

APPENDIX E

SAMPLE CALCULATIONS

Notation

p - percentage of steel

f_y - tensile stress in steel at y.p.

f'_s - compressive stress in steel

E_s - modulus of elasticity of steel

A_s - cross-sectional area of steel

A_c - cross-sectional area of concrete

e_{sh} - strain in concrete caused by shrinkage

f_t - ultimate tensile stress of concrete

E_c - modulus of elasticity of concrete

α - coefficient of thermal expansion of concrete and steel

T - maximum drop in temperature

To find necessary percentage of steel$^{(7)}$:
(See Plate 12)

$$n = \frac{E_s}{E_c} \qquad p = \frac{A_s}{A_c}$$

$$F_1 = A_c f_t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$F_2 = \alpha T p A_c E_s \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$\frac{f'_s}{E_s} = e_{sh} - \frac{f_t}{E_c} \quad \ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$F_3 = f'_s A_s = (e_{sh} E_s - n f_t) p A_c \quad \ldots \quad (4)$$

$$F = F_1 + F_2 - F_3 = A_c \left[(f_t + \alpha T p E_s) - (e_{sh} E_s - n f_t) p \right] \quad (5)$$

$$F = p A_c f_y \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

$$p = \frac{f_t}{f_s - n f_t + E_s (e_{sh} - \alpha T)} \ldots\ldots\ldots\ldots \quad (7)$$

For temperature drop $T = 85^\circ F.$

Pavement width 24 feet = 288 inches

$e_{sh} =$ 0.0005 inches/inch

$f_t =$ 750 psi

$\alpha =$ 0.000006 per degree F.

$f_s =$ 56000 psi

$E_s = 29.2 \times 10^6$

$E_c = 3 \times 10^6$

$n = 10$

$$p = \frac{750}{56000 - 10(750) + 30 \times 10^6 (5 \times 10^{-4} - 6 \times 10^{-6} \times 85)}$$

$$p = \frac{750}{48500} \times 100 \quad 1.55\%$$

For 7 inch slab - area of steel required

$$A_s = p A_c = \frac{1.55}{100} \times 288 \times 7 = 31.2 \text{ square inches}$$

For 6 inch slab - area of steel required

$$A_s = p A_c = \frac{1.55}{100} \times 288 \times 6 = 26.8 \text{ square inches}$$

It may be seen from Equation (7) that the amount of steel required to cause temperature cracking may be greatly reduced by using higher tensile strength steel and lower tensile strength concrete.

APPENDIX F

COPY OF ORIGINAL DATA

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location I **Station** 354+00

DATE OF READING	Oct.1 1958	Oct.1 1958	Oct.1 1958	Oct.2 1958	Oct.2 1958	Oct.3 1958	Oct.3 1958
AGE OF PAVEMENT IN DAYS	1.1	1.3	1.4	2.1	2.3	3	3.35
AIR TEMPERATURE	48°F	64°F	53°F	65°F	75°F	67°F	74°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	0	-108	-85	-43	-94	-25	-116
2	13	-110	-90	-50	-85	-52	-117
3	18	-117	-90	-47	-96	-47	-129
4	15	-95	-70	-40	-78	-45	-110
5	10	-110	-77	-44	-92	-45	-126
6	10	-81	-60	-20	-72	-37	-95
7	-13	-131	-111	-61	-115	-53	-136
8	-9	-102	-91	-57	-85	-57	-111
9	5	-112	-100	-49	-85	-41	-110
10	5	-115	-85	-30	-75	-48	-108
11	10	-118	-80	-50	-83	-55	-118
12	12	-95	-67	-38	-65	-43	-95
13	-17	-140	-110	-85	-105	-67	-123
14	-14	-127	-107	-72	-93	-72	-112
15	6	-102	-85	-40	-76	-35	-94
16	8	-100	-75	-35	-65	-28	-76
17	0	-82	-43	-32	-59	-27	-64
18	-1	-70	-42	-27	-57	-20	-62
19	-16	-121	-95	-80	-108	-63	-115
20	-7	-120	-90	-70	-108	-61	-118
21	2	-91	-63	-53	-84	-43	-98
22	0	-96	-65	-45	-83	-43	-95
23	2	-68	-40	-40	-71	-35	-65
24	9	-72	-38	-40	-75	-45	-77

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location 1 **Station** 364+00

DATE OF READING	Oct.4 1958	Oct.6 1958	Oct.7 1958	Oct.8 1958	Oct.9 1958	Oct.13 1958	Oct.20 1958
AGE OF PAVEMENT IN DAYS	4.0	6.3	7	8	9	13.4	20.3
AIR TEMPERATURE	46°F	53°F	50.5°F	43°F	46°F	46°F	57°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	-5	56	50	45	107	139	80
2	-22	60	68	70	77	98	58
3	-34	383	596	677	615	364	232
4	-26	335	537	605	536	304	207
5	-33	30	45	46	50	59	50
6	-25	36	40	48	30	53	49
7	-31	9	29	29	79	100	78
8	-39	21	49	48	87	97	70
9	-35	389	650	730	649	382	259
10	-25	255	485	543	444	225	140
11	-40	16	33	30	16	43	35
12	-30	28	51	50	40	70	50
13	-37	4	20	10	132	-830	-1080
14	-30	19	29	16	139	-740	-1079
15	-21	319	515	583	545	-480	-970
16	-13	295	474	535	495	-491	-995
17	-12	28	35	28	18	-690	-1113
18	-12	38	47	47	39	-672	-1107
19	-10	30	40	42	270	-571	-1020
20	-5	36	55	55	301	-545	-995
21	-23	289	451	519	457	-433	-972
22	-15	285	435	506	445	-428	-977
23	-30	-19	25	15	10	-675	-1115
24	-30	28	31	22	6	-630	-1070

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location 1 **Station** 364+00

DATE OF READING	Oct.27 1958	Nov.4 1958	Nov.5 1958	Nov.5 1958	Nov.5 1958	Nov.5 1958	Nov.6 1958
AGE OF PAVEMENT IN DAYS	27	35.5	35.9	36.0	36.3	36.4	37.3
AIR TEMPERATURE	42°F	25°F	25°F	32°F	52°F	38°F	51°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	245	195	225	211	205	175	181
2	158	206	244	198	170	201	205
3	783	854	1041	984	568	670	457
4	685	743	915	866	505	578	314
5	138	160	192	157	142	155	196
6	130	155	173	146	140	155	190
7	189	197	240	206	191	191	223
8	153	192	227	198	175	188	220
9	850	980	1168	1108	648	754	512
10	570	599	755	705	406	473	327
11	100	140	170	132	133	150	170
12	115	153	187	150	146	160	183
13	-760	0	99	69	19	27	20
14	-692	30	82	62	11	26	27
15	-225	545	687	661	338	402	214
16	-290	464	585	565	274	333	163
17	-822	-102	-72	-92	-102	-100	-72
18	-777	-81	-51	-74	-83	-76	-62
19	-515	140	242	222	65	73	30
20	-475	165	170	259	87	105	44
21	-263	419	552	527	221	279	121
22	-295	385	515	494	201	250	110
23	-820	-120	-105	-107	-137	-125	-95
24	-760	-84	-60	-80	-101	-88	-64

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location I **Station** 364+00

DATE OF READING	Nov.13 1958	Nov.27 1958	Nov.27 1958	Nov.28 1958	Nov.28 1958	Dec.5 1958	Dec.5 1958
AGE OF PAVEMENT IN DAYS	44.3	58	58.5	58.7	58.8	66.2	66.4
AIR TEMPERATURE	30°F	9°F	22°F	21°F	25°F	5.5°F	-1°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	255	305	215	205	145	315	295
2	294	328	228	228		348	328
3	903	1774	1213	1153	703	1468	1503
4	807	1563	1095	1055	765	1310	1325
5	251	305	240	210	190	325	305
6	223	276	130	90	50	295	275
7	309	467	299	219	59	499	484
8	286	438	378	368	28	458	458
9	969	1848	1240	1190	1160	1550	1595
10	715	1430	875	795	855	1195	1210
11	230	227	170	130	140	265	230
12	238	255	190	170	150	275	260
13	122	556	230	420	460	510	540
14	108	538	198	398	398	518	538
15	547	1387	675	845	835	1175	1225
16	483	1285	595	775	785	1085	1135
17	-64	138	-152	48	118	128	138
18	-22	182	-142	58	88	168	178
19	250	889	380	550	590	810	840
20	284	915	455	635	615	825	865
21	430	1177	527	697	737	977	1037
22	403	1151	485	655	725	955	1005
23	-62	115	-165	35	75	105	105
24	-32	149	-140	70	100	140	145

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location I **Station** 364+00

DATE OF READING	Jan.22 1959	Jan.22 1959	Feb.10 1959				
AGE OF PAVEMENT IN DAYS	113.7	114.3	133				
AIR TEMPERATURE	2°F	4°F	-5°F				
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	345	330	405				
2	378	368	338				
3	5683	5453	5943				
4	3075	2970	3345				
5	1355	1150	1520				
6	1215	1050	1360				
7	659	609	729				
8	613	568	688				
9	-	-	-				
10	6360	6078	6955				
11	1200	990	1370				
12	1150	960	1320				
13	680	645	750				
14	648	608	718				
15	-	-	-				
16	-	-	-				
17	908	798	1028				
18	953	828	1078				
19	925	800	1040				
20	945	825	1050				
21	8197	8022	8345				
22	8730	8650	8985				
23	435	395	475				
24	470	430	520				

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location I **Station** 364+00

DATE OF READING	Sept.30 1958	Sep 30 1958	Oct.1 1958	Oct.1 1958	Oct.1 1958	Oct.2 1958	Oct.2 1958
AGE OF PAVEMENT IN DAYS	0.1	0.3	1.1	1.3	1.4	2.1	2.3
AIR TEMPERATURE	57°F	48°F	48°F	64°F	53°F	65°F	75°F

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1							
2							
3							
4							
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1	47.5	52.8	52.8	67.6	64.5	59.0	71.6
2	52.0	53.4	53.5	69.0	64.0	62.0	75.5
3	52.0	52.4	54.0	69.5	61.5	66.0	75.5
4	52	53.4	54.8	69.0	64.0	62.4	74.8
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location I **Station** 364+00

DATE OF READING	Oct.7 1958	Oct.8 1958	Oct.9 1958	Oct.13 1958	Oct.20 1958	Oct.27 1958	Nov.4 1958
AGE OF PAVEMENT IN DAYS	7	8	9	13.4	20.3	27	35.25
AIR TEMPERATURE	50.5°F	43°F	46°F	46°F	57°F	42°F	48°F

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1	.0154					.0238	
2	.0197					.0326	
3	.0197					.0329	
4	.0183					.0334	
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1	49.0	46.7	35.2	39.0	47	34.2	38
2	49.0	46.2	35.2	38.5	49	34.2	39.5
3	50.6	48.0	40.0	38.5	51	35.1	41.5
4	49.0	47.2	36.0	38.5	47	35.1	40.0
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location I **Station** 364+00

DATE OF READING	Nov.4 1958	Nov.4 1958	Nov.5 1958	Nov.5 1958	Nov.5 1958	Nov.5 1958	Nov.6 1958
AGE OF PAVEMENT IN DAYS	35.25	35.5	35.9	36.0	36.3	36.4	37.3
AIR TEMPERATURE	44°F	33°F	25°F	32°F	52°F	36°F	51°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0204	.0294	.0338	.0336	.0209	.0238	.016
2	.0266			.0421			
3	.0266			.0410			
4	.0348	.0312	.0440	.0431	.0295	.0330	.0228
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	38	32	23.0	31.2	38.5	36.8	47.8
2	39.5	30.8	25.0	29.9	40.8	36.8	47.8
3	41.5	30.0	26.5	29.2	42.3	39.0	47.8
4	40.0	30.8	24.5	29.9	40.3	36.8	47.8
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location I **Station** 364+00

DATE OF READING	Nov.13 1958	Nov.27 1958	Nov.27 1958	Nov.27 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958
AGE OF PAVEMENT IN DAYS	44.3	58	58.2	58.5	58.7	58.8	59.0
AIR TEMPERATURE	30°F	10°F	16°F	19.5°F	14°F	25°F	27°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0252	.0415	.0355	.0340	.0340		.0325
2	.0323	.0544	.0451	.0445	.0433		.0419
3	.0325	.0480	.0401				.0418
4	.0243	.0519	.0444	.0441	.0439		.0412
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1				15.0	11.5	18.8	16.5
2				15.5	11.5	18.8	16.5
3				15.5	11.5	19.6	16.5
4				15.5	11.5	18.8	16.5
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location I **Station** 364+00

DATE OF READING	Nov.28 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958	Nov.29 1958	Nov.29 1958	Dec.5 1958
AGE OF PAVEMENT IN DAYS	59.2	59.3	59.4	59.6	59.8	60	66
AIR TEMPERATURE	38°F	30°F	30°F	29°F	28°F	27°F	5.5°F

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1	.0292	.0262	.0264	.0276			.0449
2	.0366	.0330	.0336				.0480
3		.0330	.0337	.0360			.0479
4	.0380	.0348	.0352	.0366			.0456
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1	21	24.5	23	24	23.0	22.0	4.5
2	23	24.5	26	24.5	23.0	22.5	4.5
3	21	22.5	26	24.5	23.0	22.5	5.0
4	21.5	25.0	27.5	24.5	23.0	22.5	5.0
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location I **Station** 364+00

DATE OF READING	Dec.5 1958	Jan.22 1959	Jan.22 1959	Feb.10 1959	Mar.7 1959		
AGE OF PAVEMENT IN DAYS	66.4	113.7	114.3	133	158		
AIR TEMPERATURE	-1°F	0°F	4°F	-5°F	37°F		
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0464	.0815		.0837	.039		
2	.0461	.0810		.0832			
3	.0500	.0800		.0827			
4	.0475	.0719		.0742	.026		
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	0.5	-1.0	4.0	-1.0			
2	1.5	-2.0	4.0	-2.5			
3	2.5	-1.0	4.0	-4.0			
4	1.5	-2.0	4.0	-2.5			
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location II **Station** 357+00

DATE OF READING	Oct.1 1958	Oct.2 1958	Oct.2 1958	Oct.3 1958	Oct.3 1958	Oct.4 1958	Oct.7 1958
AGE OF PAVEMENT IN DAYS	0.24	0.83	1.0	1.8	2.1	3.2	5.8
AIR TEMPERATURE	55°F	71°F	78.5°F		74°F		48.5°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	15	2	-98	8	-57	42	92
2	33	7	-48	29	-29	67	120
3	25	22	-63	65	-23	92	550
4	23	18	-32	28	-17	58	423
5	16	7	-80	16	-54	57	157
6	16	18	-67	19	-42	153	176
7	33	12	-53	28	-13	59	90
8	20	11	-49	13	-14	43	71
9	27	17	-38	23	-11	52	643
10	26	14	-62	30	-22	51	550
11	31	29	-38	34	-6	59	104
12	25	20	-43	32	-13	60	124
13	38	15	-57	35	-15	70	87
14	26	16	-49	17	-11	51	85
15	25	8	-75	25	-20	58	581
16	25	12	-65	20	-20	52	550
17	30	15	-50	24	-8	57	69
18	28	13	-47	23	-2	63	83
19	35	7	-58	19	-20	82	115
20	35	7	-65	7	-30	77	110
21	28	20	-57	31	-10	65	542
22	18	20	-55	23	-10	48	494
23	27	15	-65	22	-77	65	105
24	48	67	-43	23	+48	78	163

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type

Location **Station**

DATE OF READING	Oct.8 1958	Oct.9 1958	Oct.10 1958	Oct.14 1958	Oct.21 1958	Oct.28 1958	Nov.5 1958
AGE OF PAVEMENT IN DAYS	6.8	7.85	8.8	13	20	27	35
AIR TEMPERATURE	38°F	38°F	30°F	69°F	43°F	53°F	43°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	122	233	321	104	332	147	404
2	116	274	382	101	342	147	468
3	697	634	797	212	688	417	817
4	479	388	528	58	478	228	576
5	160	206	275	92	232	207	342
6	190	217	295	107	263	213	381
7	80	66	145	45	127	127	212
8	71	43	140	31	120	121	203
9	717	702	847	220	726	427	947
10	629	607	727	159	629	339	812
11	78	79	151	60	-	134	227
12	113	105	185	80	-	155	267
13	179	95	136	35	114	85	189
14	83	89	140	30	111	86	183
15	660	625	735	159	650	350	818
16	618	600	693	141	612	285	735
17	59	89	129	40	99	90	172
18	74	91	135	48	108	88	179
19	109	36	194	24	152	107	229
20	112	136	187	25	148	97	222
21	618	580	780	153	610	365	774
22	554	527	628	125	564	318	706
23	87	104	152	8	115	95	205
24	583	233	231	21	281	93	251

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location II **Station** 357+00

DATE OF READING	Nov.13 1958	Nov.27 1958	Nov.27 1958	Dec.5 1958	Dec.5 1958	Jan.22 1959	Jan.22 1959
AGE OF PAVEMENT IN DAYS	43	56.9	57.5	65.0	65.2	112.7	113.2
AIR TEMPERATURE	30°F	1°F	21°F	8°F	-1°F	0°F	4°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	412	916	552	812	802	1087	957
2	486	984	592	892	892	1152	1042
3	807	1997	1097	1292	1287	-	
4	606	1189	777	1052	1037	2908	2848
5	355	682	457	662	647	1257	1137
6	380	728	208	698	693	1308	1188
7	222	287	-193	287	277	317	287
8	209	276	201	286	271	321	271
9	967	1917	1347	1692	1697	10337	10112
10	851	1752	1119	1529	1519	--	--
11	223	739	489	724	704	974	899
12	256	800	565	770	755	1045	965
13	183	175	125	195	185	265	245
14	173	184	111	201	191	266	236
15	815	1681	1140	1490	1500	14075	13825
16	772	1553	1030	1370	1370	14495	14270
17	176	317	250	335	330	465	440
18	173	333	223	353	347	483	458
19	225	392	212	382	372	922	802
20	219	375	277	372	357	897	782
21	755	1475	1025	1315	1315	-	-
22	634	2328	-	1253	1288	-	-
23	195	219	145	235	215	355	315
24	179	253	-	283	363	353	-

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2
Location II **Station** 357+00

DATE OF READING	Feb.10 1959						
AGE OF PAVEMENT IN DAYS	133						
AIR TEMPERATURE	-6°F						
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	1202						
2	1252						
3	--						
4	2908						
5	1417						
6	1468						
7	357						
8	351						
9	10512						
10	--						
11	1214						
12	1315						
13	415						
14	421						
15	14300						
16	14720						
17	510						
18	533						
19	1032						
20	1027						
21	--						
22	--						
23	405						
24	523						

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location II **Station** 357+ 00

DATE OF READING	Oct.1 1958	Oct.2 1958	Oct.2 1958				Oct.7 1958
AGE OF PAVEMENT IN DAYS	0.24	0.83	1.0				5.8
AIR TEMPERATURE	55°F	71°F	78.5°F				48.5°F

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1							
2							
3							
4							
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1	58.6	61.6	72.0				47.7
2	58.7	65.5	74.8				48.3
3	58.7	71.6	78.5				48.3
4	58.9	65.5	76.5				48.7
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location II **Station** 357+00

DATE OF READING	Oct.8 1958	Oct.9 1958	Oct.10 1958	Oct.14 1958	Oct.21 1958	Oct.28 1958	Nov.5 1958
AGE OF PAVEMENT IN DAYS	6.8	7.9	8.8	13	20	27	35
AIR TEMPERATURE	38°F	38°F	30°F	69°F	43°F	53°F	43°F

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1	.0256					.0181	0.0358
2	.0166					.0133	0.0279
3	.0331					.0222	0.0368
4	.0272					.0201	0.0453
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1	41	36.2	37	53.0	36.5	48	31
2	42	35.3	35.5	57.5	37.5	48.5	33.8
3	41	37.0	33.5	61.5	38.0	49.0	36.0
4	42.5	35.0	32.5	54.0	38.4	47.5	32.8
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location II **Station** 357+00

DATE OF READING	Nov.13 1958	Nov.27 1958	Nov.27 1958	Nov.27 1958	Nov.27 1958	Nov.28 1958	Nov.28 1958
AGE OF PAVEMENT IN DAYS	43	56.9	57.1	57.3	57.5	57.7	57.8
AIR TEMPERATURE	30°F	4°F	14°F	17°F	18.5°	21°F	24°F

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1	.0316	.0613	.0543	.054	.0505		.0480
2	.0244	.0649	.0535	.057	.0566		.0465
3	.0334	.0781	.0668				.0550
4	.0338	.0699	.0610	.0615	.0580		.0550
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1				14.0	16.5	17.0	15.5
2				13.5	16.5	17.0	15.5
3				15.0	16.5	18.0	15.5
4				15.0	16.5	18.0	15.5
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location II **Station** 357+00

DATE OF READING	Nov.28 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958	Nov.29 1958	Nov.29 1958	Dec.5 1958
AGE OF PAVEMENT IN DAYS	57.9	58.1	58.1	58.2	58.6	58.7	65.1
AIR TEMPERATURE	32°F	26°F	27°F	24°F	28°F	27°F	8°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0451	.0392	.0394	.0409			.0505
2	.042	.0346	.0348	.0373			.0589
3	.0506	.0431	.0435	.0461			.068
4	.0509	.0438	.0441	.046			.0636
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	17.0	24.5	20.0	23.5	24.0	24.5	8.0
2	19.0	27.0	22.5	23.5	24.5	24.5	5.5
3	19.5	26.5	22.5	23.0	24.5	24.5	3.0
4	19.0	23.0	23.0	23.0	24.5	24.5	3.5
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUCTUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-2

Location II **Station** 357+00

DATE OF READING	Dec.5 1958	Jan.22 1959	Jan.22 1959	Feb.10 1959			
AGE OF PAVEMENT IN DAYS	65.2	112.7	113.2	133			
AIR TEMPERATURE	-1°F	0°F	4°F	-5°F			

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1	.0561	.1097		0.1170			
2	.0601	.1190		0.1290			
3	.0695						
4	.0651	.0955		.0981			
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1	9	0.0	4.0	-2.0			
2	4	-1.0	1.0	-6.0			
3	2.5	-3.5	0.5	-5.0			
4	3.5	-1.5	0.5	-4.0			
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-1
Location III **Station** 334+00

DATE OF READING	Oct.7 1958	Oct.7 1958	Oct.8 1958	Oct.8 1958	Oct.9 1958	Oct.10 1958	Oct.11 1958
AGE OF PAVEMENT IN DAYS	0.62	0.9	1.7	2	2.8	3.7	4.6
AIR TEMPERATURE	45°F	59.5°F	38°F	35°F	38°F	29°F	32°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1							
2							
3	-5	-54	15	38	114	161	215
4	-4	-61	8	38	133	154	244
5	-7	-91	1	21	48	179	96
6	-10	-93	-9	15	40	79	88
7	-5	-90	-8	-2	37	68	79
8	0	-97	-3	-1	42	68	97
9	32	-85	1	2	80	221	262
10	22	-107	-1	2	173	232	232
11	18	-106	-9	0	54	90	100
12	6	-114	-7	-2	54	91	104
13	48	-128	-1	10	-21	40	95
14	31	-166	-27	-12	-42	18	68
15	44	-150	-21	-8	-10	55	116
16	19	-152	-23	-12	-21	43	97
17	26	-164	-34	-4	125	346	426
18	21	-50	+60	+86	132	480	555
19	18	-165	-40	-9	-49	9	76
20	20	-168	-32	-8	-32	40	94
21	27	-167	-29	-11	52	63	133
22	22	-160	-27	-17	56	70	149
23	27	-160	-35	-9	19	30	100
24	-	-	-	-	-	-	-

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-1

Location III **Station** 334+00

DATE OF READING	Oct.13 1958	Oct.14 1958	Oct.15 1958	Oct.16 1958	Oct.20 1958	Oct.27 1958	Nov.3 1958
AGE OF PAVEMENT IN DAYS	7	8	8.8	9.8	14	20.7	27.8
AIR TEMPERATURE	41°F	69°F	43°F	58°F	55°F	46°F	41°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1							
2							
3	215	136	340	760	295	860	696
4	168	504	283	353	183	549	584
5	69	158	78	101	40	79	28
6	60	25	70	110	45	100	41
7	50	26	72	110	50	110	56
8	57	46	96	107	62	122	97
9	160	130	275	325	215	700	507
10	163	122	263	313	194	598	409
11	80	48	112	140	65	125	70
12	77	52	116	146	66	126	73
13	40	39	87	125	-39	160	31
14	18	18	48	88	-62	118	-22
15	44	31	85	127	10	524	262
16	40	33	78	133	18	558	318
17	144	104	336	418	51	476	234
18	266	188	464	560	171	595	262
19	20	18	49	98	-81	85	-59
20	39	0	67	113	-68	92	-46
21	71	18	93	138	28	593	332
22	64	25	110	150	30	675	396
23	40	-8	75	100	-61	95	-30
24	-	-	-	-	-	-	-

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-1

Location III **Station** 334+00

DATE OF READING	Nov.4 1958	Nov.5 1958	Nov.5 1958	Nov.5 1958	Nov.5 1958	Nov.6 1958	Nov.13 1958
AGE OF PAVEMENT IN DAYS	28.7	29.5	29.7	29.9	30	31	37.8
AIR TEMPERATURE	22°F	22°F	33°F	51°F	38°F	58°F	29°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1							
2							
3	932	1001	946	755	1137	395	945
4	628	812	790	382	451	254	636
5	69	109	109	99	107	111	131
6	86	121	130	120	128	108	140
7	102	143	146	131	140	125	160
8	118	162	158	140	149	136	175
9	870	1107	1050	476	580	307	775
10	692	903	868	408	483	273	693
11	116	163	152	150	142	140	170
12	117	164	158	150	160	152	167
13	111	238	237	200	210	84	250
14	58	189	170	150	158	60	192
15	539	823	779	329	399	119	649
16	629	923	859	369	448	130	677
17	446	698	670	351	395	174	601
18	570	810	775	474	520	297	710
19	20	150	132	114	123	18	162
20	29	160	144	132	132	31	184
21	603	913	868	383	453	160	753
22	712	1034	996	440	530	181	840
23	149	176	170	134	140	30	189
24	-	-	-	-	-	-	-

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-1

Location III **Station** 334+00

DATE OF READING	Dec.5 1958	Dec.5 1958	Jan.22 1959	Jan.22 1959	Feb.10 1959		
AGE OF PAVEMENT IN DAYS	59.9	60.0	107.5	108	127		
AIR TEMPERATURE	8°F	-1°F	0°F	4°F	-6°F		
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1							
2							
3	1965	2380					
4	1304	1304	5284	4934			
5	144	134	159	109	139		
6	140	185	130	110	140		
7	180	170	190	130	180		
8	187	192	193	157	202		
9	1490	1515	4720	4400	4770		
10	1383	1398	8783	8483	8833		
11	220	210	210	190	230		
12	196	191	186	186	211		
13	365	360	440	390	490		
14	308	298	358	338	398		
15	1249	1244	1389	1089	1459		
16	1232	1233	1368	1078	1428		
17	1011	1011	1156	936	1206		
18	1140	1140	1290	1070	1330		
19	170	165	190	145	200		
20	192	157	192	162	202		
21	1363	1358	8803	8483	8833		
22	1490	1490	-	-	-		
23	210	200	180	150	190		
24	-		-	-	-		

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-1

Location III **Station** 334+00

DATE OF READING	Oct.6 1958	Oct.7 1958	Oct.7 1958	Oct.8 1958	Oct.8 1958	Oct.9 1958	Oct.10 1958
AGE OF PAVEMENT IN DAYS	0.1	0.6	0.9	1.7	2	2.8	3.7
AIR TEMPERATURE	51°F	45°F	59.5°F	38°F	35°F	38°F	29°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1		0				0	
2							
3		0				0	
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	50.4	45	58.5	48.5	48.0	34.0	36
2	50.4	45	63.0	49.0	49.5	35.5	36
3	50.4	44	61.5	49.0	45.5	38.5	35
4	50.4	45	63.0	49.0	48.0	40.0	35.5
5	50.4	45	63.0	48.5	49.5	40.0	36
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-1

Location III **Station** 334+00

DATE OF READING	Oct.11 1958	Oct.13 1958	Oct.14 1958	Oct.15 1958	Oct.16 1958	Oct.20 1958	Oct.27 1958
AGE OF PAVEMENT IN DAYS	4.6	7	8	8.8	9.8	14	20.7
AIR TEMPERATURE	32°F	41°F	69°F	43°F	58°F	55°F	46°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1		0					.0130
2							
3		0.0009					.0134
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	34.5	43.5	53	43.5	42.0	47.6	34.0
2	34.5	44.0	56	43.5	41.5	49.5	36.0
3	33.0	44.5	59	43.0	41.0	52.4	39.5
4	34.0	44.0	56	42.5	41.5	53.6	36.5
5	34.0					48.5	34.8
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-1

Location III **Station** 334+00

DATE OF READING	Nov.3 1958	Nov.4 1958	Nov.5 1958	Nov.5 1958	Nov.5 1958	Nov.5 1958	Nov.6 1958
AGE OF PAVEMENT IN DAYS	27.8	28.7	29.5	29.7	29.9	30.0	31
AIR TEMPERATURE	41°F	22°F	22°F	33°F	51°F	38°F	58°F

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1	.0132	.0208	.0251	.0232	.0106	.0133	.0056
2							
3	.0117	.0208	.0249	.0228	.0104	.0133	.0056
4							
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1	41.0	34.4	19.0	30.0	36.0	37.0	34.8
2	41.0	33.5	20.5	30.0	38.5	36.5	38.0
3	41.6	29.0	23.0	30.0	40.8	35.2	41.5
4	41.0	24.0	19.0	30.0	38.0	36.5	38.0
5	41.0	31.0	21.0	29.6	37.5	35.2	38.0
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B7-1

Location III **Station** 334+00

DATE OF READING	Nov.13 1958	Dec.5 1958	Dec.5 1958	Jan.22 1959	Jan.22 1959	Feb.10 1959	Mar.7 1959
AGE OF PAVEMENT IN DAYS	37.8	59.9	60.0	107.5	108	127	152
AIR TEMPERATURE	29°F	8°F	1°F	0°F	4°F	-6°F	35°F

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1	.0137	.0305	.0313	.0415		.0585	.0044
2							
3	.0153	.0281	.0287	.0305		.0322	.0014
4							
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1		9.5	4.5	1.5	7.5	2.0	
2		8.0	6.0	0.5	7.0	0.5	
3		7.0	9.0	-2.0	6.0	-2.0	
4		3.5	6.5	-2.0	7.0	-0.5	
5		4.5	6.5	-2.0	8.0	-2.5	
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location IV **Station** 311+50

DATE OF READING	Oct.15 1958	Oct.16 1958	Oct.17 1958	Oct.18 1958	Oct.20 1958	Oct.21 1958	Oct.22 1958
AGE OF PAVEMENT IN DAYS	0.25	1.0	2.0	3	5	6	7
AIR TEMPERATURE	61°F	46°F	49°F	48°F	55°F	42°F	45°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	27	119	154	84	229	221	309
2	-2	148	78	35	228	353	338
3	-37	97	38	228	197	813	788
4	5	145	93	375	236	850	830
5	-15	105	72	42	238	360	360
6	10	-	-	-	-	-	-
7	-70	135	100	-90	115	160	182
8	-70	135	95	-80	130	174	195
9	-71	116	80	199	246	665	715
10	-60	130	50	215	255	770	754
11	-58	129	79	40	280	379	405
12	-50	125	70	45	276	365	395
13	-10	140	85	56	80	200	200
14	-5	153	95	65	84	178	195
15	-18	160	105	162	270	402	430
16	+15	159	96	169	271	410	432
17	+15	153	95	137	195	334	350
18	5	140	95	135	200	345	364
19	3	141	111	76	100	206	221
20	20	142	102	63	98	190	210
21	5	139	89	242	289	575	585
22	6	142	97	266	307	622	647
23	20	156	102	72	102	215	220
24	15	145	95	65	135	225	225

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location IV **Station** 311+50

DATE OF READING	Oct.23 1958	Oct.24 1958	Oct.25 1958	Oct.27 1958	Nov.5 1958	Nov.13 1958	Dec.5 1958
AGE OF PAVEMENT IN DAYS	8	9	10	14	21	28	31.25
AIR TEMPERATURE	55°F	48°F	53°F	48°F	42°F	29°F	10°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	249	329	464	499	524	529	694
2	278	388	438	478	523	550	698
3	228	578	513	758	907	991	4923
4	260	595	525	770	906	1027	5005
5	290	420	450	510	542	573	745
6	-	-	-	-	-	-	-
7	100	245	250	330	342	370	330
8	100	265	260	335	349	380	335
9	240	605	540	775	903	970	1420
10	275	655	570	795	928	1000	1475
11	280	470	490	565	601	626	805
12	280	455	470	545	574	610	755
13	130	170	150	210	236	285	260
14	135	160	155	215	217	285	265
15	340	380	385	450	480	530	615
16	340	380	380	450	474	530	600
17	255	305	325	375	400	447	530
18	265	305	315	485	421	480	435
19	156	191	191	221	251	291	271
20	160	180	170	220	-	-	-
21	350	500	445	540	574	600	850
22	387	547	487	597	649	671	927
23	149	180	180	210	222	238	200
24	160	180	180	225	230	261	225

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location IV **Station** 311+50

DATE OF READING	Dec.5 1958						
AGE OF PAVEMENT IN DAYS	51.4						
AIR TEMPERATURE	2°F						
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	684						
2	698						
3	4913						
4	4990						
5	765						
6	--						
7	345						
8	340						
9	1400						
10	1460						
11	825						
12	785						
13	270						
14	275						
15	620						
16	610						
17	445						
18	475						
19	291						
20	--						
21	830						
22	942						
23	220						
24	235						

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location IV **Station** 311+50

DATE OF READING	Oct.15 1958	Oct.16 1958	Oct.17 1958	Oct.18 1958	Oct.20 1958	Oct.21 1958	Oct.22 1958
AGE OF PAVEMENT IN DAYS	0	1	2	3	5	6	7
AIR TEMPERATURE	45°F	46°F	49°F	50°F	55°F	42°F	45°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1							
2							
3				0.0105			
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	46.5	44.5	46.8	48.5	51.5	39.5	38.0
2	51.0	44.0	46.4	48.5	49.0	38.0	38.0
3	55.0	45.0	47.6	48.5	49.5	38.5	38.0
4	53.0	46.0	46.8	48.5	49.5	38.5	38.0
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location IV **Station** 311+50

DATE OF READING	Oct.23 1958	Oct.24 1958	Oct.25 1958	Oct.29 1958	Nov.5 1958	Nov.13 1958	Dec.5 1958
AGE OF PAVEMENT IN DAYS	8	9	10	14	21	28	51.2
AIR TEMPERATURE	55°F	48°F	53°F	48°F	42°F	29°F	51.4
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1							
2							
3			.0121	.0186	.0226	.0197	.0316
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	48.0	43.5	42.0	40.0	34.0		10.0
2	46.5	41.2	40.0	40.5	31.5		10.0
3	49.5	43.5	44.5	41.2	38.0		10.0
4	48.0	41.2	42.0	41.2	35.2		10.0
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location IV **Station** 311+50

DATE OF READING	Dec.5 1958	Feb.10 1959	Mar.7 1959				
AGE OF PAVEMENT IN DAYS	51.4	118	143				
AIR TEMPERATURE	2°F	-5°F	35°F				

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1							
2							
3	.0324	.0445	.018				
4							
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1	3.5						
2	4.5						
3	2.0						
4	3.5						
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location V **Station** 307+00

DATE OF READING	Oct.16 1958	Oct.17 1958	Oct.18 1958	Oct.20 1958	Oct.21 1958	Oct.22 1958	Oct.23 1958
AGE OF PAVEMENT IN DAYS	0.25	1	2	4	5	6	7
AIR TEMPERATURE	68°F	49°F	60°F	54°F	43°F	45°F	55°F

SR-4 STRAIN GAGES (MICRO-IN./IN.)

Gage No. 1	5	360	235	42	25	-10	-20
2	0	352	205	10	20	-10	-40
3	-4	328	180	75	619	625	+15
4	-6	330	181	91	611	621	+16
5	-9	342	180	130	203	281	-14
6	-	-	-	-	-	-	-
7	20	371	221	-10	-45	-65	-90
8	9	359	202	-20	-51	+20	-100
9	21	349	209	159	645	660	80
10	9	352	202	140	640	650	50
11	18	358	200	15	10	-25	-50
12	18	339	207	18	13	-12	-52
13	-5	105	135	156	255	275	195
14	-30	75	100	121	210	220	160
15	-10	95	118	277	725	764	295
16	-21	112	138	285	790	840	315
17	-12	100	110	138	232	243	190
18	-9	102	126	147	246	251	191
19	-24	96	136	167	246	255	205
20	-6	109	135	190	265	270	220
21	+2	90	122	352	842	907	367
22	-6	107	147	360	880	958	375
23	-11	110	149	170	241	260	210
24	0	128	155	185	250	255	220

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location V **Station** 307+00

DATE OF READING	Oct.24 1958	Oct.25 1958	Oct.30 1958	Nov.6 1958	Nov.13 1958	Dec.5 1958	Dec.5 1958
AGE OF PAVEMENT IN DAYS	8	9	14	21	28	50.2	50.3
AIR TEMPERATURE	45°F	53°F	54°F	60°F	29.5°F	9°F	5.5°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	10	0	-25	-31	-105	-150	-140
2	-1	-20	-55	-88	-109	-140	-110
3	610	225	95	11	632	8760	8655
4	606	226	41	16	611	9096	8971
5	201	181	101	85	121	276	281
6	-	-	-	-	-	-	-
7	-75	-90	-115	-151	-195	-325	-290
8	-80	-100	-130	-161	-200	-310	-305
9	635	295	120	95	695	950	885
10	622	250	85	70	651	935	870
11	-10	-35	-60	-93	-121	-205	-195
12	-2	-22	-42	-80	-107	-202	-192
13	310	285	264	301	365	315	335
14	270	251	240	253	309	255	270
15	795	545	415	412	947	6480	6385
16	830	580	450	451	1070	6835	6745
17	300	280	270	280	332	295	295
18	306	281	271	292	331	261	286
19	316	291	271	295	356	296	311
20	320	300	285	294	340	300	310
21	862	587	457	449	1089	-	-
22	905	615	465	477	1161	10405	10345
23	289	290	270	283	340	240	280
24	309	300	285	298	342	2	290

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location V **Station** 307+00

DATE OF READING	Jan.22 1959	Jan.22 1959					
AGE OF PAVEMENT IN DAYS	97.8	98.2					
AIR TEMPERATURE	-1°F	4°F					

SR-4 STRAIN GAGES (MICRO-IN./IN.)

Gage No. 1	-190	-190					
2	-160	-200					
3	--	--					
4	--	--					
5	+221	+191					
6	--	--					
7	-355	-380					
8	-360	-380					
9	875	+475					
10	875	+470					
11	-235	-265					
12	-242	-267					
13	300	280					
14	230	225					
15	--	--					
16	--	--					
17	240	215					
18	211	216					
19	256	241					
20	260	240					
21	--	--					
22	--	--					
23	235	220					
24	205	230					

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location V **Station** 307+00

DATE OF READING	Oct.23 1958	Oct.24 1958	Oct.25 1958	Oct.30 1958	Nov.6 1958	Nov.13 1958	Dec.5 1958
AGE OF PAVEMENT IN DAYS	7	8	9	14	21	28	50.2
AIR TEMPERATURE	55°F	45°F	53°F	54°F	60°F	29.5°F	9°F

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1	-.0004	-	-0.0008	-0.0006	-0.001	-0.0013	-
2	-.006	-0.0027	-0.0056	-0.0058	-0.0024	0.0055	.0297
3	.006	.0111	0.0092	0.0079	0.0106	0.0214	.0430
4							
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1	47.2	38.0	35.5	41.5	41.5		6.0
2	48.0	39.0	39.0	45.5	45.0		6.0
3	51.0	40.5	42.5	49.5	50.5		5.0
4	48.5	40.0	41.0	47.2	46.8		4.0
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location V **Station** 307+00

DATE OF READING	Dec.5 1958	Jan.22 1959	Jan.22 1959	Feb.10 1959	Mar.7 1959		
AGE OF PAVEMENT IN DAYS	50.3	97.8	98.2	117	142		
AIR TEMPERATURE	5.5°F	-1°F	+4°F	-5°F	35°F		
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	--	--		--			
2	0.03	0.038		.034			
3	0.043	0.0487		.0507	.021		
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	3.0	-0.5	4.0				
2	5.0	-0.5	6.5				
3	5.5	-2.5	6.0				
4	3.0	-2.5	6.5				
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location V **Station** 307+00

DATE OF READING	Oct.16 1958	Oct.16 1958	Oct.17 1958	Oct.18 1958	Oct.20 1958	Oct.21 1958	Oct.22 1958
AGE OF PAVEMENT IN DAYS	0	0.25	1.0	2.0	4	5	6
AIR TEMPERATURE	41°F	68°F	49°F	60°F	54°F	43°F	45°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1					-0.001		
2					-0.007		
3					0.0047		
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	38.5	58.0	48.5	52.0	51.0	40.0	39.5
2	36.5	67.2	49.0	52.4	51.0	39.0	39.5
3	36.5	72.0	49.0	52.4	50.5	39.0	39.5
4	36.5	67.2	49.5	52.8	49.5	39.5	39.5
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1
Location VI **Station** 304+00

DATE OF READING	Oct.16 1958	Oct.17 1958	Oct.18 1958	Oct.20 1958	Oct.21 1958	Oct.22 1958	Oct.23 1958
AGE OF PAVEMENT IN DAYS	0.25	1	2	4	5	6	7
AIR TEMPERATURE	63°F	52°F	54°F	52°F	45°F	43°F	53°F

SR-4 STRAIN GAGES (MICRO-IN./IN.)

Gage No. 1	254	221	249	319	384	379	314
2	-522	60	90	150	211	190	135
3	+457	98	88	212	688	770	178
4	-787	62	82	160	655	745	150
5	306	64	81	193	336	336	231
6	161	69	94	193	338	336	228
7	244	89	115	144	191	168	131
8	-104	71	92	122	182	152	117
9	-525	66	96	206	598	641	221
10	-269	69	99	217	575	635	235
11	+582	73	103	192	293	293	203
12	-20	69	100	176	289	280	200
13	-10	50	82	110	152	150	90
14	-15	50	80	110	154	140	75
15	-34	41	77	190	295	300	195
16	-11	54	88	179	284	289	189
17	-18	39	64	131	212	212	130
18	-37	65	72	136	223	209	143
19	-28	45	78	99	145	140	85
20	-19	48	85	116	156	151	86
21	-30	55	75	122	169	147	100
22	-11	63	101	149	224	174	124
23	0	68	98	171	245	235	180
24	-24	46	74	154	234	234	169

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VI **Station** 304+00

DATE OF READING	Oct.24 1958	Oct.25 1958	Oct.30 1958	Nov.6 1958	Nov.27 1958	Nov.27 1958	Nov.27 1958
AGE OF PAVEMENT IN DAYS	8	9	14	21	42	42.2	42.3
AIR TEMPERATURE	35°F	55°F	66°F	59°F	0°F	12°F	12°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	374	384	374	394	540	454	154
2	195	200	220	220	258	412	138
3	868	353	233	243	-	1911	1548
4	835	335	220	238	-	1880	1737
5	341	331	331	337	1200	801	492
6	343	327	318	329	378	850	300
7	171	176	196	196	-	268	94
8	157	152	187	185	497	292	98
9	698	371	291	287	9684	1252	1072
10	680	370	300	292	-	1232	812
11	303	268	278	270	613	553	213
12	290	270	280	275	1060	526	301
13	140	140	170	160	88	220	40
14	135	145	175	161	445	226	43
15	310	295	295	281	2074	650	449
16	289	289	294	284	1755	625	479
17	210	215	240	220	1056	456	170
18	228	223	243	233	835	462	94
19	135	140	175	152	495	232	90
20	140	146	176	164	506	246	69
21	150	165	180	363	3548	291	112
22	164	164	194	183	4624	264	-51
23	240	230	255	250	220	471	140
24	229	224	249	241	-126	489	262

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VI **Station** 304+00

DATE OF READING	Nov.27 1958	Nov.27 1958	Nov.28 1958	Nov.29 1958			
AGE OF PAVEMENT IN DAYS	42.5	42.6	42.8	43.9			
AIR TEMPERATURE	12°F	21°F	19°F	22°F			
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	284	304	314	104			
2	252	240	270	-50			
3	1628	1598	1548	1138			
4	1710	1680	1680	1300			
5	635	651	691	361			
6	548	538	628	318			
7	56	76	146	62			
8	125	182	82	142			
9	1064	1086	1126	836			
10	1015	1010	1120	760			
11	411	453	493	383			
12	366	430	440	330			
13	86	120	150	40			
14	85	115	165	-5			
15	489	525	545	365			
16	459	509	519	389			
17	287	320	380	160			
18	282	293	367	203			
19	50	80	140	80			
20	66	136	136	136			
21	98	150	180	160			
22	104	134	184	94			
23	308	340	400	290			
24	324	364	404	304			

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type 86-1

Location VI **Station** 304+00

DATE OF READING	Oct.16 1958	Oct.16 1958	Oct.17 1958	Oct.18 1958	Oct.20 1958	Oct.21 1958	Oct.22 1958
AGE OF PAVEMENT IN DAYS	0	0.25	1	2	4	5	6
AIR TEMPERATURE	53°F	63°F	52°F	54°F	52°F	45°F	43°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1					.0030		
2					.0024		
3					.0022		
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	50.5	60.5	50.0	48.5	49.0	39.5	40.0
2	56.4	65.0	50.5	49.0	49.0	39.0	40.0
3	56.8	69.5	52.5	50.0	49.0	41.2	40.0
4	56.0	64.0	52.0	50.0	49.0	40.0	40.0
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VI **Station** 304+00

DATE OF READING	Oct.23 1958	Oct.24 1958	Oct.25 1958	Oct.30 1958	Nov.6 1958	Nov.13 1958	Nov.27 1958
AGE OF PAVEMENT IN DAYS	7	8	9	14	21	22	41
AIR TEMPERATURE	53°F	35°F	55°F	66°F	59°F	38°F	0°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0042		.0075	.0060	.0088	.0188	
2	.0038		.0072	.0051	.0064	.0167	
3	.0040		.0049	.0039	.0059	.0094	
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	50.0	38.0	41.5	46.0	41.0		
2	51.0	36.5	44.0	49.0	43.0		
3	52.5	37.5	48.0	55.5	46.0		
4	51.0	37.5	44.0	49.0	42.5		
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VI **Station** 304+00

DATE OF READING	Nov.27 1958	Nov.27 1958	Nov.27 1958	Nov.27 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958
AGE OF PAVEMENT IN DAYS	42.2	42.3	42.5	42.6	42.8	42.9	43.0
AIR TEMPERATURE	12°F	12°F	12°F	21°F	19°F	27°F	31°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0456		.0436				
2	.032		.031				0.024
3	.020		.020				0.015
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1			12.0	11.5	12.0	15.0	20.0
2			12.5	11.5	12.0	15.0	22.0
3			13.0	11.5	12.0	15.0	24.0
4			15.5	11.5	12.0	15.0	22.0
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VI **Station** 304+00

DATE OF READING	Nov.28 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958	Feb.10 1959	
AGE OF PAVEMENT IN DAYS	43.2	43.3	43.5	43.6	43.9	117	
AIR TEMPERATURE	31°F	29°F	24°F	27°F	22°F	-6°F	
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1							
2	.018	.019	.023			.0423	
3	.013	.013	.014			.0215	
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	21.5	23.0	22.0	23.5	24.0		
2	23.5	25.5	22.0	23.5	24.0		
3	26.0	28.5	22.0	23.5	24.0		
4	24.0	25.5	22.0	23.5	24.0		
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VII **Station** 303+00

DATE OF READING	Oct.16 1958	Oct.17 1958	Oct.18 1958	Oct.21 1958	Oct.22 1958	Oct.23 1958	Oct.24 1958
AGE OF PAVEMENT IN DAYS	0.3	1	2	5	6	7	8
AIR TEMPERATURE	65°F	54°F	56°F	46°F	44°F	54°F	34°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	-11	45	39	200	195	140	210
2	-5	25	57	214	200	115	205
3	-50	49	68	580	700	122	800
4	-4	45	65	555	675	111	765
5	-7	43	57	218	223	116	233
6	0	45	62	212	217	112	217
7	5	94	35	125	50	63	110
8	0	40	55	155	120	70	110
9	14	43	54	624	665	168	785
10	-18	23	39	634	769	175	874
11	-23	35	55	133	145	65	133
12	-8	33	67	133	123	63	133
13	-28	50	92	169	150	97	140
14	-32	41	84	172	147	100	152
15	-48	40	83	640	810	155	920
16	-19	56	89	586	711	171	791
17	-27	50	90	180	160	87	155
18	-33	69	66	155	131	62	116
19	-21	39	20	160	130	89	115
20	-22	53	88	168	150	95	138
21	-32	57	87	675	855	209	950
22	-30	49	89	639	780	190	848
23		70	120	190	180	110	170
24	-10	55	108	170	165	108	155

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VII **Station** 303+00

DATE OF READING	Oct.25 1958	Oct.25 1958	Oct.30 1958	Nov.4 1958	Nov.5 1958	Nov.5 1958	Nov.5 1958
AGE OF PAVEMENT IN DAYS	9.1	9.3	14	19	19.8	20.0	20.3
AIR TEMPERATURE	55°F	50°F	68°F	23°F	22°F	37°F	53°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	225	115	215	270	310	308	267
2	225	115	235	273	307	308	285
3	270	172	185	862	1083	957	392
4	260	175	175	840	1057	927	382
5	233	109	243	287	335	325	288
6	232	107	237	278	322	313	281
7	135	90	165	165	196	197	201
8	135	100	160	158	188	196	190
9	295	205	235	797	1016	954	421
10	304	183	234	1042	1284	1144	532
11	125	85	160	185	213	210	193
12	103	83	148	147	173	173	164
13	150	140	185	180	209	208	204
14	162	142	202	205	232	232	227
15	335	220	280	1031	1250	1110	564
16	301	232	266	761	935	839	436
17	240	140	275	305	341	341	320
18	241	112	236	259	291	297	283
19	155	139	195	178	200	200	215
20	173	138	208	211	231	230	238
21	415	275	320	1085	1312	1183	615
22	350	260	280	801	1010	935	472
23	185	140	-	205	234	231	235
24	170	145	185	210	243	230	234

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VII **Station** 303+00

DATE OF READING	Nov.5 1958	Nov.6 1958	Nov.13 1958	Dec.5 1958	Dec.5 1958	Jan.22 1959	Jan.22 1959
AGE OF PAVEMENT IN DAYS	20.5	21.17	28	50.0	50.15	98	98
AIR TEMPERATURE	38°F	61°F	24°F	7°F	2°F	-2°F	4°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	265	251	292	495	520	555	515
2	265	260	307	525	550	545	520
3	510	216	810	12860	13710	14555	-
4	505	192	765	-	-	-	-
5	278	258	315	548	593	578	568
6	269	252	301	522	562	563	558
7	177	186	184	150	195	120	135
8	170	179	190	155	195	105	130
9	410	254	867	9855	9690	-	-
10	689	274	934	-	-	-	-
11	185	184	204	185	195	145	165
12	153	163	171	158	173	103	123
13	190	197	202	185	220	360	290
14	218	214	227	212	257	402	332
15	712	310	900	1625	1550	-	-
16	521	261	763	1521	1461	-	-
17	305	280	340	870	890	1020	980
18	275	254	285	741	776	901	851
19	192	210	198	630	660	725	690
20	228	228	226	688	728	798	748
21	750	371	971	3575	3495	-	-
22	550	248	850	4925	4820	-	-
23	210	244	225	230	260	170	160
24	215	230	227	230	270	190	160

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VII **Station** 303+00

DATE OF READING	Feb.10 1959						
AGE OF PAVEMENT IN DAYS	117						
AIR TEMPERATURE	-6°F						

SR-4 STRAIN GAGES (MICRO-IN./IN.)

Gage No. 1	460						
2	485						
3	14940						
4	-						
5	1448						
6	1363						
7	155						
8	140						
9	-						
10	-						
11	1285						
12	1193						
13	440						
14	482						
15	-						
16	-						
17	1300						
18	1131						
19	850						
20	928						
21	-						
22	-						
23	236						
24	290						

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VII **Station** 303+00

DATE OF READING	Oct.16 1958	Oct.16 1958	Oct.17 1958	Oct.18 1958	Oct.20 1958	Oct.21 1958	Oct.22 1958
AGE OF PAVEMENT IN DAYS	0	0.3	1	2	4.3	5	6
AIR TEMPERATURE	60°F	65°F	54°F	56°F	50°F	46°F	44°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1					.0011		
2					.0031		
3					.0007		
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	62.0	61.0	52.8	50.5	52.5	40.0	40.4
2	59.5	62.5	53.2	50.5	52.5	40.0	40.8
3	62.5	67.5	57.2	52.0	52.5	42.0	40.8
4	61.5	64.5	56.0	52.0	52.5	40.0	40.8
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VII **Station** 303+00

DATE OF READING		Oct.23 1958	Oct.24 1958	Oct.25 1958	Oct.30 1958	Nov.4 1958	Nov.5 1958	Nov.5 1958
AGE OF PAVEMENT IN DAYS		7	8	9.1	14	19	19.8	20.0
AIR TEMPERATURE		54°F	34°F	55°F	68°F	23°F	22°F	37°F
CRACK WIDTH MEASUREMENTS (INCHES)								
Plug No.	1	.0034		.0057	.0048	.0266	.030	.0250
	2	.0040		.0091	.0072			.032
	3	.0026		.0067	.0046	.0187	.023	.0204
	4							
	5							
	6							
	7							
	8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)								
Gage No.	1	47.2	33.5	40.4	45.0	30.0	28.0	29.6
	2	48.5	33.5	41.2	50.0	29.6	26.0	29.6
	3	52.8	33.5	46.4	55.5	84.4	24.0	30.0
	4	50.0	33.5	43.0	52.8	29.6	26.0	29.6
	5							
	6							
	7							
	8							
	9							
	10							
	11							
	12							
	13							
	14							
	15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VII **Station** 303+00

DATE OF READING	Nov.5 1958	Nov.5 1958	Nov.6 1958	Nov.13 1958	Dec.5 1958	Dec.5 1958	Jan.22 1959
AGE OF PAVEMENT IN DAYS	20.3	20.5	21.2	28	50.0	50.2	98
AIR TEMPERATURE	53°F	38°F	61°F	24°F	7°F	2°F	-2°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0135	.0182	.007	.0161	.0504	.049	.10
2			.0081	.0241	.0516	.050	.109
3	.0096	.0137	.0056	.0096	.0374	.0364	.089
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	39.0	36.5	37.5		7.0	6.5	-5.5
2	39.0	35.6	41.2		8.0	5.0	-5.5
3	40.0	34.0	43.0		7.5	2.5	-3.5
4	38.5	34.8	39.5		7.5	3.5	-4.0
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-1

Location VII **Station** 303+00

DATE OF READING	Jan.22 1959	Feb.10 1959	Mar.7 1959				
AGE OF PAVEMENT IN DAYS	98	117	142				
AIR TEMPERATURE	4°F	-6°F	35°F				
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1		.1860	.0695				
2		.1142					
3		.0685	.0331				
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	4.5						
2	4.0						
3	3.5						
4	3.0						
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location VIII **Station** 294+00

DATE OF READING	Oct.20 1958	Oct.21 1958	Oct.22 1958	Oct.23 1958	Oct.24 1958	Oct.25 1958	Oct.27 1958
AGE OF PAVEMENT IN DAYS	0.4	1	2	3.2	4	5.25	7.2
AIR TEMPERATURE	49°F	49°F	43°F	53°F	32°F	52°F	60°F

SR-4 STRAIN GAGES (MICRO-IN./IN.)

Gage No. 1	8	120	128	43	128	273	228
2	101	181	186	121	201	311	271
3	83	165	175	100	190	235	135
4	80	165	165	95	180	230	110
5	74	165	165	95	160	215	165
6	49	150	150	75	165	195	145
7	88	173	168	103	173	178	123
8	88	160	155	75	150	155	110
9	92	181	177	87	177	297	177
10	81	161	166	81	166	261	141
11	85	162	170	85	175	190	140
12	90	173	180	95	185	205	155
13	101	146	121	70	161	181	121
14	80	131	116	21	151	161	96
15	76	150	125	40	170	300	160
16	88	139	110	30	150	280	150
17	75	145	115	50	157	175	125
18	79	139	94	39	149	169	124
19	80	131	88	38	138	163	108
20	79	131	69	41	131	156	101
21	77	141	122	77	162	307	172
22	75	140	105	65	140	290	180
23	55	135	94	50	120	155	100
24	65	130	95	65	120	160	120

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location VIII **Station** 294+00

DATE OF READING	Oct.29 1958	Oct.30 1958	Nov.3 1958	Nov.4 1958	Nov.5 1958	Nov.5 1958	Nov.5 1958
AGE OF PAVEMENT IN DAYS	9	10.4	14	15	15.9	16.1	16.3
AIR TEMPERATURE	52°F	45°F	45°F	23°F	20°F	36°F	48°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	328	228	287	368	405	386	350
2	371	301	319	408	443	423	404
3	535	120	462	904	1063	816	395
4	560	125	530	1041	1210	992	472
5	260	190	216	305	325	308	302
6	235	170	186	274	300	285	271
7	208	178	166	248	264	246	268
8	185	155	240	221	236	218	229
9	592	196	545	1077	1209	1022	520
10	551	171	513	1030	1161	963	501
11	230	200	210	280	295	281	285
12	240	210	199	277	293	275	286
13	221	201	206	256	271	271	293
14	211	181	182	240	265	259	276
15	590	215	597	1135	1270	1089	619
16	555	210	531	1052	1183	1003	562
17	220	195	197	255	275	275	295
18	114	194	185	238	259	243	287
19	203	178	160	228	256	248	258
20	196	161	151	221	250	237	249
21	562	222	532	1074	1191	1002	572
22	510	205	459	935	1047	905	504
23	205	165	178	239	257	255	268
24	205	165	166	220	235	233	255

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location VIII **Station** 294+00

DATE OF READING	Nov.5 1958	Nov.6 1958	Nov.13 1958	Nov.27 1958	Nov.27 1958	Nov.27 1958	Nov.27 1958
AGE OF PAVEMENT IN DAYS	16.4	17.2	24	38.1	38.25	38.33	38.5
AIR TEMPERATURE	38°F	60°F	24°F	5°F	14°F	16°F	
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	343	294	371	624	608	-623	408
2	399	351	411	652	639	-803	414
3	508	178	825	6129	5735	4126	5326
4	615	189	878	8722	8312	7886	7937
5	305	255	294	473	443	-700	277
6	267	227	270	434	405	-1627	136
7	240	223	228	288	263	-1562	-20
8	210	190	212	269	240	-272	98
9	657	202	921	-	-	-	-
10	631	181	867	-	-	-	-
11	265	229	260	316	1050	-344	156
12	275	235	280	315	1073	-855	125
13	266	245	267	283	681	-499	161
14	251	221	245	261	499	-403	143
15	755	250	972	8323	8010	7070	7541
16	680	240	910	9477	9146	8628	8679
17	262	-	245	274	387	-235	155
18	239	250	235	249	402	-515	109
19	228	226	228	240	380	-388	87
20	221	223	230	257	379	37	133
21	690	280	895	7330	7160	6587	6577
22	600	271	802	8415	8157	7326	7685
23	235	243	234	278	403	-273	135
24	222	249	210	220	340	-90	112

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location VIII **Station** 294+00

DATE OF READING	Nov.27 1958	Nov.28 1958	Dec.5 1958	Dec.5 1958	Jan.22 1959	Jan.22 1959	Feb.10 1959
AGE OF PAVEMENT IN DAYS	38.7	38.8	46.2	46.33	94	94	113
AIR TEMPERATURE	22°F	19°F	7°F	10°F	-4°F	3°F	-6°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	408	458	588	608	648	553	672
2	41	471	621	636	651	601	676
3	5135	5195	5815	5625	-	-	-
4	7840	7890	8380	8175	-	-	-
5	145	375	440	450	815	635	855
6	-285	285	405	420	795	665	845
7	-332	98	258	278	1388	1033	1518
8	230	90	225	260	1350	1140	1430
9							
10							
11	110	220	285	290	280	320	330
12	125	205	280	300	275	325	295
13	181	201	271	311	291	231	301
14	81	201	261	301	261	221	286
15	7450	7570	8060	7900	-	-	-
16	8600	8730	9250	9095	-	-	-
17	25	215	275	295	185	175	235
18	-91	189	229	249	169	149	209
19	-72	188	228	263	168	138	188
20	191	199	251	281	191	161	201
21	6542	6642	7092	6952	-	-	-
22	7505	7765	8195	8050	-	-	-
23	85	225	255	290	175	180	205
24	100	180	200	240	140	130	170

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location VIII **Station** 294+00

DATE OF READING	Oct.20 1958	Oct.20 1958	Oct.21 1958	Oct.22 1958	Oct.23 1958	Oct.24 1958	Oct.25 1958
AGE OF PAVEMENT IN DAYS	0	0.4	1	2	3.2	4	5.25
AIR TEMPERATURE	32.5°F	49°F	49°F	43°F	53°F	32°F	52°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1					0		.0022
2					0		.0023
3							
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	44.5	55.0	44.5	38.5	46.4	33.5	40.0
2	46.8	55.0	45.0	38.5	50.0	34.0	42.0
3	46.8	55.0	45.5	38.5	51.0	34.0	45.0
4	47.6	55.0	45.0	38.5	50.0	34.0	44.5
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location VIII **Station** 294+00

DATE OF READING	Oct.27 1958	Oct.29 1958	Oct.30 1958	Nov.3 1958	Nov.4 1958	Nov.5 1958	Nov.5 1958
AGE OF PAVEMENT IN DAYS	7.2	9	10.4	14	15	15.9	16.1
AIR TEMPERATURE	60°F	52°F	45°F	45°F	23°F	20°F	36°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0011	.0092	.0028	.0116	.0208	.0240	.0187
2	.0020	.0074	.0030	.0092	.0192	.0216	.0169
3							
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	43.5	36.5	47.6	40.4	23.5	15.5	31.5
2	47.2	38.5	47.2	40.4	24.5	17.5	32.0
3	48.5	39.0	47.2	40.4	26.0	19.4	32.0
4	47.2	39.0	47.6	40.4	25.5	18.5	32.0
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location VIII **Station** 294+00

DATE OF READING	Nov.5 1958	Nov.5 1958	Nov.6 1958	Nov.13 1958	Nov.27 1958	Nov.27 1958	Nov.27 1958
AGE OF PAVEMENT IN DAYS	16.3	16.4	17.2	24	38.2	38.3	38.5
AIR TEMPERATURE	48°F	38°F	60°F	24°F	14°F	16°F	22°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0104	.0142	.0038	.0154	.0374	.0442	
2	.0082	.0118	.0026	.0141	.0410	.0554	
3							
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	35.6	35.5	36.0	27.5			
2	36.0	34.5	38.5	27.5			
3	36.5	33.5	39.5	27.5			
4	36.0	33.0	39.0	27.5			
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location VIII **Station** 294+00

DATE OF READING	Nov.27 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958
AGE OF PAVEMENT IN DAYS	38.7	38.8	38.9	39	39.25	39.35	39.6
AIR TEMPERATURE	22°F	19°F	29°F	26.5°F	34°F	30°F	26°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0332		.0297	.0272	.0234	.0226	.0244
2	.0368		.0341	.0312	.0252	.0254	.0280
3							
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	15.0	15.5	17.0	13.5	24.0	26.0	28.5
2	15.0	15.5	17.0	16.0	26.5	26.5	29.2
3	15.0	15.5	17.0	17.0	27.5	27.0	28.5
4	15.0	15.5	17.0	17.0	27.5	27.0	28.5
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location VIII **Station** 293+00

DATE OF READING	Nov.29 1958	Nov.29 1958	Dec.5 1958	Dec.5 1958	Jan.22 1959	Jan.22 1959	Feb.10 1959
AGE OF PAVEMENT IN DAYS	39.7	39.9	46.2	46.3	93.9	94.1	113
AIR TEMPERATURE	30°F	26°F	7°F	10°F	-3°F	10°F	-6°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1			.0342	.0338	.0605		.0626
2			.0430	.0421	.0735		.0750
3							
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	27.0	27.0	5.5	10	-3.0		-3.5
2	27.0	27.0	6.5	8.0	-4.0		-5.0
3	27.5	27.0	8.0	8.0	-4.0		-3.5
4	27.5	27.0	8.5	7.5	-4.0		-4.5
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location IX **Station** 289+50

DATE OF READING	Oct.20 1958	Oct.21 1958	Oct.22 1958	Oct.23 1958	Oct.24 1958	Oct.25 1958	Oct.27 1958
AGE OF PAVEMENT IN DAYS	0.2	0.9	1.9	3	3.9	5.1	7.1
AIR TEMPERATURE	45°F	48°F	41°F	55°F	31°F	53°F	58°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	+41	80	112	80	155	280	220
2	+30	70	29	25	65	270	190
3	46	88	67	43	93	213	193
4	21	56	41	31	66	246	181
5	35	70	55	45	80	170	105
6	43	71	81	50	111	161	116
7	26	46	5	15	55	220	165
8	155		0	-40	15	165	170
9	33	60	29	32	65	280	180
10	-123	50	85	64	115	345	235
11	34	-	-	-	-	-	-
12	70	90	78	55	120	178	115
13	65	55	-25	-25	-10	95	5
14	100	100	41	0	70	145	50
15	43	40	-10	-47	8	228	93
16	114	95	65	25	90	295	150
17	48	60	17	-18	23	148	38
18	80	59	30	0	50	140	40
19	57	28	42	-43	12	78	-22
20	100	70	25	5	45	115	45
21	75	75	25	-10	50	125	110
22	69	19	10	-40	50	205	65
23							
24	10	20	-15	-66	15	65	-15

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location IX **Station** 289+50

DATE OF READING	Oct.29 1958	Oct.30 1958	Nov.3 1958	Nov.13 1958	Dec.5 1958	Dec.5 1958	Jan.22 1959
AGE OF PAVEMENT IN DAYS	8.9	10.2	14	24	46	46	94
AIR TEMPERATURE	50°F	45°F	43°F	25°F	4°F	4°F	3°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	350	260	352	446	1035	1025	1050
2	250	240	350	434	1015	1030	1000
3	323	253	313	388	873	853	1163
4	311	216	284	379	876	861	1141
5	205	160	177	225	380	405	530
6	211	156	192	241	376	401	551
7	290	220	285	369	1050	975	1115
8	285	215	301	360	1085	1015	1155
9	540	225	477	590	1215	1320	1300
10	515	265	545	680	1375	1275	1460
11	-	-	-	-	-	-	-
12	220	165	216	230	250	770	245
13	125	140	142	133	170	210	680
14	185	170	180	184	225	275	715
15	418	188	397	635	1473	1303	1228
16	525	255	535	805	1775	1595	1455
17	158	158	159	148	203	273	178
18	155	160	138	149	155	200	125
19	98	98	197	82	118	158	88
20	150	160	148	137	125	175	100
21	480	210	448	718	1650	1475	1290
22	458	160	500	786	1520	1350	1055
23							
24	105	120	115	110	70	125	75

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location IX **Station** 289+50

DATE OF READING	Feb.10 1959						
AGE OF PAVEMENT IN DAYS	113						
AIR TEMPERATURE	-5°F						
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	1125						
2	1100						
3	1398						
4	1351						
5	600						
6	631						
7	1245						
8	1305						
9	1500						
10	1685						
11	-						
12	270						
13	810						
14	850						
15	1558						
16	1765						
17	193						
18	140						
19	133						
20	135						
21	1540						
22	1320						
23	-						
24	45						

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location IX **Station** 289+50

DATE OF READING	Oct.20 1958	Oct.20 1958	Oct.21 1958	Oct.22 1958	Oct.23 1958	Oct.24 1985	Oct.25 1958
AGE OF PAVEMENT IN DAYS	0	0.2	0.9	1.9	3	3.9	5.1
AIR TEMPERATURE	52°F	45°F	48°F	41°F	55°F	31°F	53°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1							.0036
2							.0042
3							.0034
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	49.5	52.0	45.0	40.8	49.0	35.0	42.5
2	46.4	51.0	45.5	40.4	51.0	34.0	45.5
3	42.5	50.5	46.0	40.8	52.5	33.0	48.0
4	45.5	51.0	45.5	40.8	51.5	33.5	46.5
5	45.5	51.0	45.5	40.8	51.5	33.0	46.0
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location IX **Station** 289+50

DATE OF READING	Oct.27 1958	Oct.29 1958	Oct.30 1958	Nov.3 1958	Nov.13 1958	Dec.5 1958	Dec.5 1958
AGE OF PAVEMENT IN DAYS	7.1	8.9	10.2	14	24	46.0	46.1
AIR TEMPERATURE	58°F	50°F	45°F	43°F	25°F	4°F	4°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0037	.0100	.0049	.0128	.0170	.030	.0280
2	.0038	.0104	.0056	.0134	.0212	.0366	.0322
3	.0030	.0120	.0039	.0122	.0187	.0381	.0348
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	45.5	40.5	46.5	40.4	29.2	1.0	11.0
2	48.0	42.0	46.0	40.8	28.4	3.0	8.8
3	52.5	44.0	46.5	41.6	28.4	3.5	7.5
4	50.5	43.0	46.5	40.4	28.4	3.5	7.5
5	49.5	42.5	47.2	40.4	28.4	4.0	8.0
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type B6-2

Location IX **Station** 289+50

DATE OF READING	Jan.22 1959	Jan.22 1959	Feb.10 1959				
AGE OF PAVEMENT IN DAYS	93.9	94.1	113				
AIR TEMPERATURE	-5°F	3°F	-5°F				

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1	.0316		.0342				
2	.0321		.0357				
3	.0307		.0336				
4							
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1	-0.5	8.0	0.5				
2	1.0	6.5	0.5				
3	6.0	8.5	0.5				
4	3.0	6.0	0.5				
5	2.0	8.0	0				
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type A-6

Location X **Station** 262+50

DATE OF READING	Oct.29 1958	Oct.30 1958	Oct.31 1958	Nov.1 1958	Nov.3 1958	Nov.4 1958	Nov.4 1958
AGE OF PAVEMENT IN DAYS	0.7	2	3.2	3.7	6	7.3	6.9
AIR TEMPERATURE	52°F	57°F	49°F	50°F	41°F	23°F	44°F

SR-4 STRAIN GAGES (MICRO-IN./IN.)

Gage No.							
1	100	120	390	339	392	548	449
2	140	160	370	322	379	503	416
3	145	145	1100	551	660	1900	640
4	140	150	910	432	482	1540	442
5	125	140	640	487	525	979	609
6	125	475	685	460	487	900	551
7	145	-295	195	171	165	231	164
8	145	155	200	171	163	232	151
9	135	585	1290	790	810	1738	538
10	140	-20	1370	862	956	2104	782
11	125	-715	170	155	157	215	145
12	140	75	200	179	183	260	179
13	90	100	140	122	121	166	116
14	85	100	115	97	86	136	190
15	80	95	1205	669	922	2025	812
16	90	105	1225	683	915	1677	627
17	80	80	105	83	63	110	63
18	75	75	100	69	40	112	48
19	95	150	135	109	85	154	91
20	30	70	75	40	29	82	36
21	85	115	1140	590	859	2051	1000
22	75	110	1010	493	697	1589	820
23	60	100	75	60	59	120	66
24	60	105	85	65	61	106	65

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type A-6

Location X **Station** 262+50

DATE OF READING	Nov.5 1958	Nov.5 1958	Nov.5 1958	Nov.13 1958	Nov.27 1958	Nov.27 1958	Nov.28 1958
AGE OF PAVEMENT IN DAYS	7.6	8	8.1	16.0	29.7	29.8	30.3
AIR TEMPERATURE	20°F	46°F	39°F	22°F	2°F	19°F	17°F
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	547	528	507	519	510	485	410
2	472	468	466	440	435	416	380
3	979	640	628	583	1150	768	550
4	700	418	430	560	870	562	390
5	908	591	530	626	829	731	470
6	822	517	480	552	774	645	390
7	203	204	215	189	135	135	105
8	212	207	210	190	158	145	120
9	730	200	244	400	880	311	220
10	1112	502	236	621	1118	523	430
11	192	173	184	164	105	105	85
12	240	230	232	217	176	172	140
13	150	162	165	132	74	91	30
14	121	131	135	95	45	175	15
15	920	385	412	166	895	380	305
16	755	215	239	316	767	245	175
17	83	92	94	55	5	35	-10
18	84	95	95	42	-12	23	-35
19	109	127	125	85	15	45	-5
20	64	77	74	35	-18	10	-50
21							
22	769	270	190	290	770	278	150
23	55	79	62	40	-25	-5	-50
24	60	83	71	43	-25	-5	-45

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type A-6

Location X **Station** 262+50

DATE OF READING	Dec.5 1958	Dec.5 1958	Jan.22 1959	Jan.22 1959	Feb.10 1959		
AGE OF PAVEMENT IN DAYS	37.8	38.0	84.7	85.1	104		
AIR TEMPERATURE	-3.5°F	4°F	-5°F	3°F	-6°F		
SR-4 STRAIN GAGES (MICRO-IN./IN.)							
Gage No. 1	195	210	450	440	470		
2	475	470	430	370	435		
3	1480	780	850	445	820		
4	1160	590	640	275	590		
5	885	835	890	400	730		
6	805	670	640	355	660		
7	160	195	125	75	115		
8	215	200	160	100	150		
9	1120	460	520	20	470		
10	1380	690	750	200	590		
11	140	165	115	45	95		
12	200	230	190	120	170		
13	110	120	50	70	70		
14	75	115	35	85	55		
15	1165	585	505	35	525		
16	1035	445	405	-75	405		
17	30	80	5	35	10		
18	5	105	-15	45	-15		
19	50	95	15	60	25		
20	0	50	-45	-10	35		
21	-	-	-	-	-		
22	1005	445	1010	520	1050		
23	5	40	-50	-45	-40		
24	0	45	-50	-50	-30		

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type A-6

Location X **Station** 262+50

DATE OF READING	Oct.29 1958	Oct.30 1958	Oct.31 1958	Nov.1 1958	Nov.3 1958	Nov.4 1958	Nov.4 1958
AGE OF PAVEMENT IN DAYS	0.7	2	3.2	3.7	6	6.9	7.3
AIR TEMPERATURE	52°F	57°F	49°F	50°F	41°F	44°F	23°F

CRACK WIDTH MEASUREMENTS (INCHES)

Plug No. 1		.0005	.0237	.0187	.0262	.0240	.048
2		.0005	.0219	.0158	.0257	.0282	
3		.0007	.0195	.014	.0240	.0270	.046
4							
5							
6							
7							
8							

PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)

Gage No. 1	48.5	56.5	43.5	49.0	39.5	39.0	33
2	50.0	58.0	45.0	49.5	39.5	40.0	34
3	52.0	60.0	45.5	49.5	39.5	41.0	35
4	49.5	60.0	45.5	49.5	39.5	40.0	34.5
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type A-6
Location X **Station** 262+50

DATE OF READING	Oct.29 1958	Oct.30 1958	Oct.31 1958	Nov.1 1958	Nov.3 1958	Nov.4 1958	Nov.4 1958
AGE OF PAVEMENT IN DAYS	0.7	2	3.2	3.7	6	6.9	7.3
AIR TEMPERATURE	52°F	57°F	49°F	50°F	41°F	44°F	23°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1		.0005	.0237	.0187	.0262	.0240	.048
2		.0005	.0219	.0158	.0257	.0282	
3		.0007	.0195	.014	.0240	.0270	.046
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	48.5	56.5	43.5	49.0	39.5	39.0	33
2	50.0	58.0	45.0	49.5	39.5	40.0	34
3	52.0	60.0	45.5	49.5	39.5	41.0	35
4	49.5	60.0	45.5	49.5	39.5	40.0	34.5
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type A-6

Location X **Station** 262+50

DATE OF READING	Nov.5 1958	Nov.5 1958	Nov.5 1958	Nov.5 1958	Nov.13 1958	Nov.27 1958	Nov.27 1958
AGE OF PAVEMENT IN DAYS	7.6	7.7	8	8.1	15.7	29.7	29.8
AIR TEMPERATURE	20°F	36°F	46°F	39°F	32°F	2°F	19°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0366	.024	.0216	.0268	.0236	.0274	.0226
2		.026			.0264	.0335	.0235
3	.0410	.028	.0235	.0188	.0222	.0305	.0238
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	28.8	30.5	39.0	36.0	28.8		
2	27.5	30.5	39.0	36.0	28.8		
3	25.5	31.5	37.5	35.5	28.8		
4	26.0	31.0	36.5	35.5	28.4		
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type A-6

Location X **Station** 262+50

DATE OF READING	Nov.27 1958	Nov.27 1958	Nov.27 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958	Nov.28 1958
AGE OF PAVEMENT IN DAYS	29.9	30.0	30.2	30.3	30.4	30.6	30.7
AIR TEMPERATURE	17°F	15°F	21.5°F	17°F	28°F	28°F	31°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1		.0196	.0182		.0142	.0132	.0143
2		.0215	.0206		.0139	.0126	.0095
3		.0211	.0202		.0176	.0160	.0137
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1			12	15.0	15.5	14.0	18.8
2			12	14.5	15.5	14.5	21.0
3			12	14.5	15.5	15.5	22.0
4			13	16.0	15.5	16.0	25.0
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type A-6

Location X **Station** 262+50

DATE OF READING	Nov.28 1958	Nov.28 1958	Nov.29 1958	Nov.29 1958	Dec.5 1958	Dec.5 1958	Jan.22 1959
AGE OF PAVEMENT IN DAYS	31.0	31.2	31.3	31.5	37.8	38	85
AIR TEMPERATURE	31°F	23°F	27°F	26°F	-3.5°F	4°F	-5°F
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0142	.0230			.0280	.0214	.0235
2	.0102	.0120			.0380	.0288	.0248
3	.0140	.0158			.0367	.0276	.0274
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	21.0	25.5	22.5	23.5	2.5	7.5	-2.0
2	23.0	26.0	22.5	23.5	2.0	7.5	-1.0
3	24.0	26.0	22.5	23.5	2.0	5.0	-0.5
4	26.0	26.0	24.5	25.5	2.0	6.0	-0.5
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							

INSTRUMENTATION DATA

TEST ROAD — BOWNESS, ALBERTA

Section Type A-6

Location X **Station** 262+50

DATE OF READING	Feb.10 1959						
AGE OF PAVEMENT IN DAYS	104						
AIR TEMPERATURE	-6°F						
CRACK WIDTH MEASUREMENTS (INCHES)							
Plug No. 1	.0221						
2	.0241						
3	.0262						
4							
5							
6							
7							
8							
PAVEMENT TEMPERATURE (DEGREES FAHRENHEIT)							
Gage No. 1	-3.0						
2	-3.0						
3	-4.0						
4	-4.0						
5							
6							
7							
8							
9							
10							
11							
12							
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15							

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